# With or Without: Empirical Analyses of Disparities in Health Care Access and Quality

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**Abstract**

The existence of unfair differences or disparities in access to and quality of health care is well known. However, the nature of disparities at different stages of the health seeking pathway and interventions to reduce them are less clear. Applying the tools of statistics and quasi experimental design-- interrupted time series, propensity score matching, hierarchical models— we can analyze how care is accessed in low, middle and high income countries and assess for disparities. The results are sometimes surprising and underscore the need to generate context specific evidence to ensure targeting of programs.

My first paper evaluates the impact of a controversial policy, mandating of health insurance, on reducing disparities in health care access and affordability. Using longitudinal survey data from five states in USA (2002-2009), I show that living in MA, where health insurance is mandated, results in a higher probability of being insured and having a personal doctor and lower probability in forgoing care due to costs as compared to similar border states. The beneficial effect of the mandate is greatest in traditionally "disadvantaged" groups defined by race, income, education or employment status.

My second paper examines gender disparities in access to medicines in sub Saharan Africa-- Uganda, Kenya, Nigeria, Ghana, Gambia. Using medicines specific survey data, I construct a

novel seven stage access to medicines pathway and assess gender disparities along it applying the Institute of Medicine framework. Contrary to prevailing belief, I find few gender differences in unadjusted outcomes which cease to be significant on controlling for health status and country characteristics.

My third paper assesses disparities by educational attainment in process and outcomes of care. I use unique data extracted from an electronic medical record of diabetic patients in Mexico City. Using a matching algorithm, I control for only differences in health need and find few significant differences in processes and outcomes of care. The unmatched traditional regression based risk adjustments tend to overestimate the significance and magnitude of the association.

The three papers demonstrate the need to use more sophisticated statistical tools to appropriately measure disparities and ensure the effectiveness of health programs.

## Table of Contents

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In honor of my grandmother,

Ija

who started her PhD in 1940

completed on her behalf in 2012

and my family,

Girija, Bharoti, Rahul Pande

and my *jaadu*, Ziad Haider

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# Chapter 1:

## Effects of health care reforms on coverage, access, and disparities: Quasi-experimental analysis of evidence from Massachusetts[a]

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## Abstract

### Background

The 2010 Patient Protection and Affordable Care Act (PPACA) has been controversial. The potential impact of national health care reform may be considered using a similar set of state-level reforms including exchanges and a mandate, enacted in 2006 in Massachusetts.

### Purpose

To evaluate the effects of reforms on health care access, affordability and disparities.

### Design

Interrupted time series with comparison series.

### Setting/Participants

Longitudinal survey data from 2002 to 2009 from the Behavioral Risk Factor Surveillance System including 178,040 non-elderly adults residing in Massachusetts, Vermont, New Hampshire, Rhode Island and Connecticut. Analysis was conducted from January-August 2010.

### Intervention

Massachusetts 2006 health care reform, which included an individual health insurance mandate.

### Main Outcome Measure

Being uninsured, having no personal doctor, and forgoing care due to cost, evaluated in Massachusetts and four comparison states before (2002-2005) and after (2007-2009) the health care reform. Effects on disparities defined by race, education, income and employment were also assessed.

**Results**

Living in Massachusetts in 2009 was associated with a 7.6 percentage point (3.9, 11.3) higher probability of being insured, 4.8 percentage point (-0.9,10.6) lower probability of forgoing care due to cost, and a 6.6 percentage point (1.9, 11.3) higher probability of having a personal doctor, compared to expected levels in the absence of reform, defined by trends in control states and adjusting for socio-economic factors. The effects of the reform on insurance coverage attenuated from 2008 to 2009. In a socio-economically disadvantaged group, the reforms had a greater effect in improving outcomes on the absolute but not relative scale.

**Conclusions**

Health care reforms in Massachusetts, which included a health insurance mandate, were associated with significant increases in insurance coverage and access. The absolute effects of the reform were greater for disadvantaged populations. This is important evidence to consider as debate over national health reform continues.

## Introduction

The 2010 Patient Protection and Affordable Care Act (PPACA) expands insurance coverage and mandates health insurance for most Americans.[1,2] These reforms have been particularly controversial. Opponents have symbolically repealed the bill in the US House of Representatives. Virginia and Florida courts have exempted residents from the individual mandate and the ongoing legal case against the mandate is likely to be decided eventually by the US Supreme Court.[3]

The experience of Massachusetts (MA) provides evidence on the impact of similar state health care reforms. In April 2006, MA legislature enacted comprehensive health reform requiring all state residents to carry a minimum level of health insurance, subject to penalties for non-compliance starting in 2008.[4] To make coverage more affordable the reform expanded Medicaid, subsidized private insurance, and set up the Commonwealth Connector to help individuals find suitable insurance. While an estimated 406,000 people have gained insurance in MA between June 2006 and March 31, 2009,[5] attributing causal effects to the reforms has been challenging.

Studies examining the effects of MA reforms in specific health care facilities are limited, have mixed results, and are difficult to generalize.[6,7] Surveys within MA before and after the reform have indicated higher insurance coverage, access, and use of health care in the post-reform period.[8,9,10,11,12,13] However, the pre-post design of these studies does not control for underlying secular trends and the lack of comparison to areas outside of Massachusetts might fail to account for regional trends. One prior study[13] using difference-in-difference methods to compare insurance coverage in Massachusetts and three control states (New Jersey, New York and Pennsylvania) found a significant drop in uninsurance among non-elderly adults in Massachusetts, but its design did not adjust for secular trends or consider outcomes other than insurance.

To our knowledge, only one other study has looked at the effect of MA reform on a similar range of outcomes.[14] However, this study did not examine data before the reform, so could not account for pre-existing trends. Previous literature suggests that MA had unique factors leading up to the reforms such as a lower rate of uninsurance; broader Medicaid participation; and a generous, taxpayer-funded pool of money for uncompensated care.[15] The prior study's small sample sizes limited its ability to discern effects within specific racial and economic subgroups. The study also only tracked the impact of the reform until 2008 and thus failed to observe results after the beginning of the economic downturn.[11]

This study uses longitudinal survey data over an eight-year period and a strong quasi-experimental design to examine a range of policy-relevant outcomes, both overall and in the disadvantaged groups that were its main target. The objective is to provide rigorous empirical evidence on the potential immediate and medium-term impacts of the MA reforms, including its individual insurance mandate, on health care outcomes.

## Methods

### Study Design

The 2006 MA health care reforms were exploited as a naturally occurring quasi-experiment and trends in key outcomes were evaluated from 2002-2009, using an interrupted time series with comparison series design, the strongest observational design for making causal inference.[16] Analysis was conducted from January-August 2010. All study participants in MA were considered to be exposed to the reforms, including the health insurance mandate (i.e. an "intention to treat" design), and those living in Rhode Island, Vermont, New Hampshire and Connecticut constituted the comparison group. These four states border MA and have similar socio-economic environments.

The comparability of the sample was assessed. Next, the unadjusted differences in the study outcomes (overall and for specific subgroups) were examined before and after the reform. Finally, an individual-level interrupted time series analyses was run to control for potential differences between the samples over time. A similar subgroup analysis of the effects of the reform on disparities was conducted.

### Data Source

Publicly available data from the Behavioral Risk Factor Surveillance System (BRFSS), an annual cross-sectional telephone survey of the civilian, non-institutionalized population that is designed and funded by the Centers for Disease Control and Prevention and conducted by states was used.[17] Households are contacted through random digit dialing. Since the effects of the reform are expected to be greatest for non-elderly adults not yet eligible for Medicare, the analysis was limited to respondents ages 18 to 64.

**Outcome Measures**

The primary outcomes were responses to three questions: (1) "Do you have any kind of health care coverage, including health insurance, prepaid plans such as HMOs, or government plans such as Medicare?" (2) "Do you have one person you think of as your personal doctor or health care provider?" (Respondents who answered "no" were asked to clarify whether there was more than one person or no person.) (3) "Was there a time in the past 12 months when you needed to see a doctor but could not because of cost?" For the third question, the analysis was restricted to 2003-2009 due to inconsistent wording in 2002.

Several individual-level covariates were included to adjust predictions: age, sex, marital status, education, employment, household size, and household income. Race was categorized as non-Hispanic white, non-Hispanic black, Hispanic, and other/mixed race. Annual household income was categorized as <$25,000; $25,000 - $49,999; and ≥$50,000. [20] Education was classified as having completed high school or not. Employment categories distinguished wage employment, self-employment, and all other categories (being unemployed, retired, homemaker, student, or unable to work). Marital status was classified as being married compared to never married, divorced, widowed, separated, or a member of an unmarried couple.

## Statistical Analyses

An interrupted time series analysis of individual data was used to estimate changes in the three outcomes before and after 2006. Using logistic regression models, the primary independent variables of interest were terms capturing changes in outcomes in 2007, 2008, and 2009 in Massachusetts, compared to those in control states. To aid interpretation, coefficients from the models were used to predict the adjusted effects on the percentage scale. The effects were expressed as the probability of each outcome for a standard population living in MA minus the counterfactual probability of the outcome had the population not been exposed to the 2006 reform. The analyses was run on 100 bootstrapped samples and the mean and standard error of the bootstrapped estimates were used to determine confidence intervals.

The effect of the reform on disparities was examined. A “disadvantaged” group was defined that had characteristics associated with uninsurance at baseline. The disadvantaged group included people who were black, Hispanic, of other/mixed race, self-employed, with less than high school education, or an annual household income below $50,000. Similar interrupted time series models were used to examine how changes differed in the two groups on both the relative and absolute scales. The significance of relative effects was evaluated with two-sided tests of the coefficients that captured the effects of the reform in MA in 2007, 2008, and 2009.[19] Absolute effects were determined by predicting the effects in the disadvantaged compared to advantaged groups using the coefficients from the interrupted time series models.

**Sensitivity Analyses**

Three sensitivity analyses were run. First, the model was run in the survey sub-sample that was 65 years or older. This population already had high levels of insurance through Medicare so should have been minimally affected by the reform; differences in outcomes observed may signify other uncontrolled factors such as the economic downturn. Second, the models were re-estimated excluding one control state at a time to evaluate the robustness of the results to the choice of controls. Third, the model specification was tested by running two alternative models, one in which the effects of the reform were assumed to change linearly (on the logistic scale) after 2006 and another in which equal trends in MA and control states before 2006 were assumed.

All tests were 2-sided with $p<0.05$ considered statistically significant. BRFSS sampling weights and post-stratification adjustments were used to account for differences in probabilities of selection and non-response, and to partially correct for non-coverage of non-telephone households.[17] All analyses were performed using Stata, version 10.1 (Stata Corp, College Station, Texas).

## Results

The study population (n= 178,040) represented nearly 5 million US adults ages 18 to 64 living in MA and the four control states over the seven analysis years. At baseline the groups had similar composition in terms of household size, sex, education, wage employment, and income (Table 1). The average age in both groups was 40 years, and both samples comprised 51 percent females, with overwhelming majorities having at least a high school education. MA had a different racial mix before and after the reforms which likely reflects year-to-year sampling differences. Race was controlled for in the final model to account for these differences.

### Overall Effects

Unadjusted estimates show a significant decrease in uninsurance rates and in forgoing care due to cost in MA compared to control states, with the greatest decrease in 2008 (Figure 1). Uninsurance in MA decreased from 11.0 percent in 2002 (95 per cent CI: 10.0, 12.1) to 5.1 percent (4.5, 5.8) in 2008, increasing slightly to 6.5 percent (5.5, 7.4) in 2009. Uninsurance rates in the control states were relatively flat from 13.3 percent (12.4, 14.1) in 2002 to 12.3 (11.4, 13.3) in 2009. Although there was a decrease in the MA respondents not having a personal doctor in 2007, differences were substantially reduced in the next two years.

Adjusting for individual covariates in the time-series regression models, the interaction terms between MA and the post-reform years were found to be significant, suggesting that MA residents were significantly more likely to be insured and have a personal doctor, and significantly less likely to forgo care due to cost, compared to expected levels in the absence of reform, defined by trends in the comparison states (Table 2). Living in Massachusetts in 2009

**Table 1: Characteristics of the study population before and after the 2006 reforms**

| | 2002-2005 | | 2007-2009 | | Both Periods Combined | |
|---|---|---|---|---|---|---|
| **Characteristic** | **MA** | **Control States** | **MA** | **Control States** | **MA** | **Control States** |
| *n* | *24,829* | *61,935* | *40,353* | *50, 923* | *65, 182* | *112, 858* |
| *Mean (SD)* | | | | | | |
| Age | **39.9 (.1)** | **40.5 (.1)** | 41.0 (.1) | 41.4 (.1) | **40.4 (.1)** | **40.9 (.1)** |
| Household Size | 3.2 (.0) | 3.2 (.0) | **3.3 (.0)** | **3.2 (.0)** | **3.3 (.0)** | **3.2 (.0)** |
| *Frequency (SD)* | | | | | | |
| Male | 49.0 (.4) | 49.3 (.3) | 49.1 (.4) | 49.5 (.4) | 49.0 (.3) | 49.4 (.2) |
| Education (>High School) | 92.6 (.2) | 93.1 (.2) | **93.6 (.2)** | **94.8 (.2)** | **93.0 (.2)** | **93.9 (.1)** |
| Married | **56.5 (.4)** | **60.1 (.3)** | 60.9 (.4) | 62.30 (.4) | **58.4 (.3)** | **61.1 (.2)** |
| Employment | | | | | | |
| Self-Employed | **9.2 (.2)** | **10.2 (.2)** | 8.8 (.2) | 10.0 (.2) | **9.0 (.2)** | **10.3 (.1)** |
| Wage Employed | 64.5 (.4) | 61.9 (.4) | **66.3 (.4)** | **64.4 (.4)** | 65.2 (.3) | 65.1 (.2) |
| Race | | | | | | |
| White | **81.6 (.3)** | **84.9 (.3)** | **78.4 (.4)** | **85.5 (.3)** | **80.2 (.3)** | **85.2 (.2)** |
| Black | 3.9 (.2) | 3.7 (.1) | **5.2 (.2)** | **3.2 (.1)** | **4.4 (.1)** | **3.5 (.1)** |
| Hispanic | **9.2 (.3)** | **7.2 (.2)** | **9.3 (.3)** | **6.6 (.2)** | **9.3 (.2)** | **6.9 (.1)** |
| Other/ Mixed | **5.3 (.2)** | **4.2 (.1)** | **7.2 (.2)** | **4.7 (.2)** | **6.1 (.2)** | **4.4 (.1)** |
| Annual Household Income | | | | | | |
| < $25,000 | **17.4 (.3)** | **16.2 (.2)** | **16.0 (.3)** | **13.5 (.3)** | **16.8 (.2)** | **15.0 (.2)** |
| $25,000-$49,999 | **24.0 (.4)** | **25.8 (.3)** | 18.7 (.3) | 19.5 (.3) | **21.7 (.3)** | **23.0 (.2)** |
| > $50,000 | 58.6 (.4) | 58.0 (.3) | 65.3 (.4) | 67.0 (.4) | 61.5 (.3) | 62.0 (.2) |

***Bold*** *indicates a significant difference at p <.05*

**Figure 1:** Unadjusted annual estimates of study outcomes over time in Massachusetts and control states. Columns show results in (1) the overall sample; (2) the disadvantaged subsample; (3) the advantage subsample. Rows show outcomes for (1) percent uninsured; (2) percent unable to see a doctor due to cost and (3) percent not having a personal physician.

Disadvantaged group is defined as black, Hispanic, other race, low income, with less than high school education, or self-employed; advantaged group is defined as white, high income, with at least a high school education, or not self-employed.

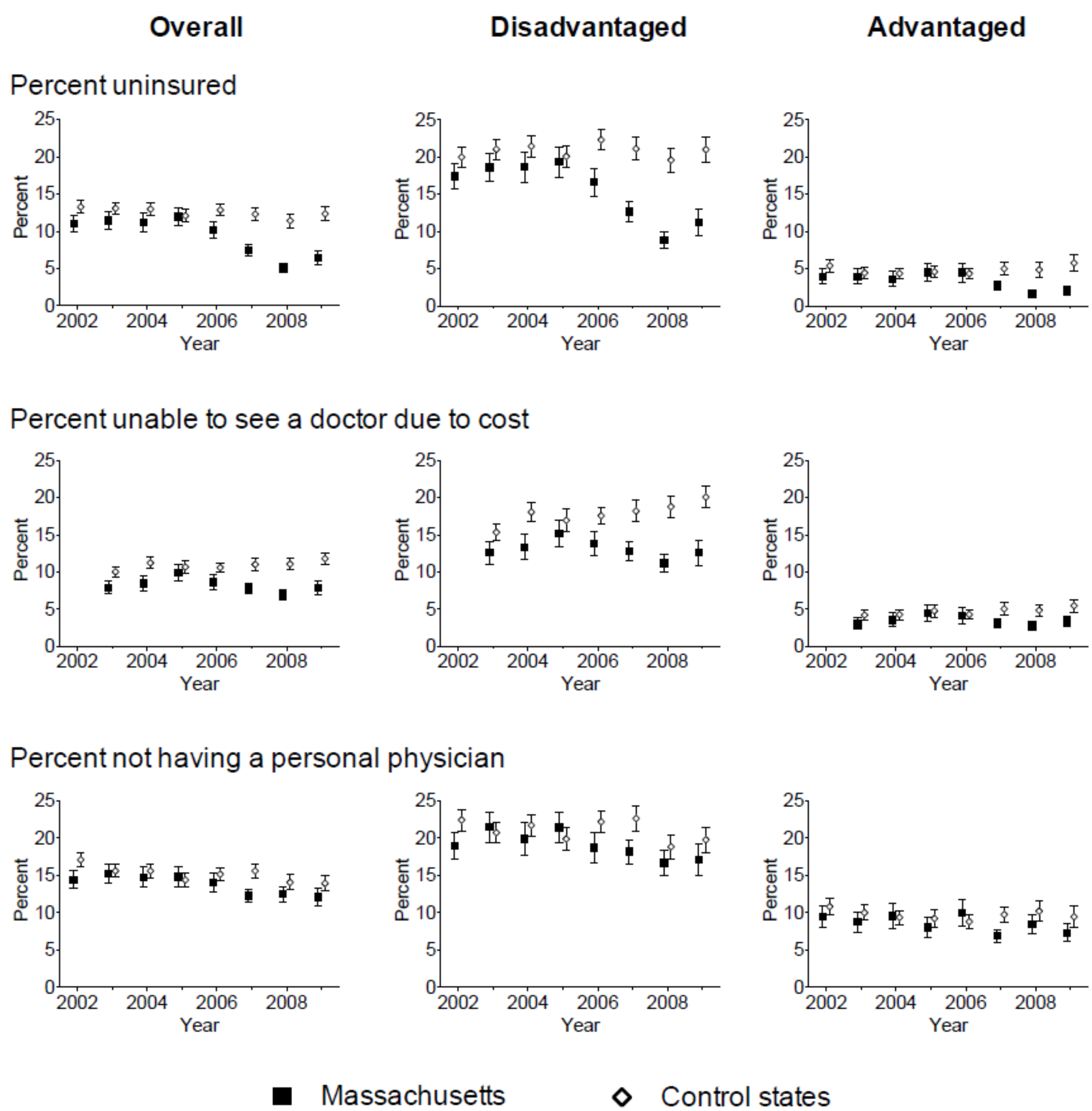


**Table 2: Adjusted impacts of the Massachusetts health insurance mandate showing the reforms to have a significant effect on study outcomes**

| Variables* | No health insurance *n = 159,795* | | Medical cost as barrier *n= 141,701* | | No personal doctor *n = 159,811* | |
|---|---|---|---|---|---|---|
| | Odds Ratio | *(95 % CI)* | Odds Ratio | *(95 % CI)* | Odds Ratio | *(95 % CI)* |
| Massachusetts | 0.93 | *(0.76 ,1.13)* | 0.82 | *(0.63 ,1.06)* | 1.06 | *(0.89 ,1.27)* |
| Year | 0.99 | *(0.95 ,1.03)* | **1.07** | *(1.00 ,1.15)* | **0.95** | *(0.92 ,0.99)* |
| Change in Level | 1.04 | *(0.86 ,1.25)* | 0.93 | *(0.76 ,1.15)* | **1.28** | *(1.08 ,1.52)* |
| Change in Trend | 1.03 | *(0.95 ,1.12)* | 0.99 | *(0.90 ,1.09)* | 1.00 | *(0.92 ,1.08)* |
| Massachusetts x Year | 1.05 | *(0.98 ,1.13)* | 1.05 | *(0.93 ,1.18)* | **1.08** | *(1.01 ,1.15)* |
| Massachusetts x 2007† | **0.55** | *(0.41 ,0.75)* | 0.80 | *(0.54 ,1.19)* | **0.67** | *(0.51 ,0.87)* |
| Massachusetts x 2008† | **0.29** | *(0.20 ,0.42)* | **0.55** | *(0.33 ,0.90)* | **0.59** | *(0.43 ,0.82)* |
| Massachusetts x 2009† | **0.35** | *(0.22 ,0.55)* | **0.54** | *(0.29 ,1.00)* | **0.56** | *(0.38 ,0.83)* |
| Black | **1.34** | *(1.16 ,1.55)* | **1.27** | *(1.11 ,1.44)* | **1.14** | *(1.00 ,1.3)* |
| Hispanic | **1.99** | *(1.81 ,2.19)* | **1.37** | *(1.23 ,1.53)* | **1.99** | *(1.81 ,2.17)* |
| Other | **1.23** | *(1.07 ,1.41)* | **1.48** | *(1.27 ,1.72)* | **1.54** | *(1.37 ,1.73)* |
| Low Income (<$25,000) | **6.07** | *(5.49 ,6.72)* | **5.45** | *(4.92 ,6.04)* | **2.52** | *(2.32 ,2.74)* |
| Middle Income ($25,000-$49,999) | **3.81** | *(3.50 ,4.16)* | **3.42** | *(3.13 ,3.73)* | **1.79** | *(1.67 ,1.91)* |
| Household Size | **1.04** | *(1.01 ,1.06)* | **1.05** | *(1.03 ,1.08)* | **0.96** | *(0.94 ,0.98)* |
| High School Education or more | **0.58** | *(0.52 ,0.65)* | **0.84** | *(0.75 ,0.94)* | **0.74** | *(0.67 ,0.82)* |
| Employed for Wages | **0.81** | *(0.75 ,0.87)* | **0.77** | *(0.72 ,0.83)* | 1.07 | *(1.00 ,1.15)* |
| Self-Employed | **2.58** | *(2.35 ,2.84)* | **1.52** | *(1.37 ,1.68)* | **1.67** | *(1.52 ,1.84)* |
| Married | **0.57** | *(0.53 ,0.61)* | **0.74** | *(0.68 ,0.80)* | **0.76** | *(0.71 ,0.81)* |
| Age | **0.98** | *(0.98 ,0.99)* | **0.99** | *(0.99 ,0.99)* | **0.96** | *(0.96 ,0.96)* |
| Male | **1.77** | *(1.66 ,1.88)* | **0.90** | *(0.84 ,0.96)* | **2.24** | *(2.13 ,2.37)* |

†*Main predictors of interest, estimating the effect of the MA reform in 2007, 2008 and 2009, in relation to the expected levels under no reform defined by trends in comparison states.* *Massachusetts is a dummy variable capturing if the individual lived in MA or not; year is an integer variable ranging from –4 for data from 2002 to 3 for data from 2009; change in level is a dummy variable coded 0 if the data were from before 2006 and 1 if after; and change in trend is a variable coded 0 if the data were from before 2006, 1 if 2007, 2 if 2008 and 3 if 2009.

***Bold*** *is results significant at the .05 level.*

was associated with a 65 percent (95% confidence interval: 45, 78) reduction in the odds of being uninsured, a 46 percent (0.2, 71) reduction in the odds of forgoing care due to cost, and a 44 percent (17, 62) reduction in the odds of not having a personal doctor, adjusting for race, income, household size, education, employment, age, sex and marital status. The magnitude of the protective effect on uninsurance rates attenuated from 2008 to 2009.

On adjusting for known confounders, by 2009 the reforms were associated with a 7.6 percentage point (3.9, 11.3) higher probability of being insured, 4.8 percentage point (-0.9,10.6) lower probability of forgoing care due to cost, and a 6.6 percentage point (1.9, 11.3) higher probability of having a personal doctor for an average person in the population.

**Socially Disadvantaged Subgroup Analyses**

Unadjusted estimates show that the disadvantaged group (n=96,327) experienced substantially poorer outcomes overall than the advantaged group (n=84,871) prior to the reforms (Figure 1). After the reforms, there were significant decreases in uninsurance rates and forgoing care due to cost for both groups.

The adjusted time series models for the disadvantaged group revealed that in 2009 the reforms resulted in a 63 percent (40, 77) reduction in the odds of being uninsured in MA compared to the comparison states, a 49 percent (0.1, 74) reduction in the odds of forgoing care due to cost, and a 51 percent (22, 70) reduction in the odds of not having a personal doctor. For the advantaged group, living in MA resulted in a significant reduction only in uninsurance rates compared to comparison states.

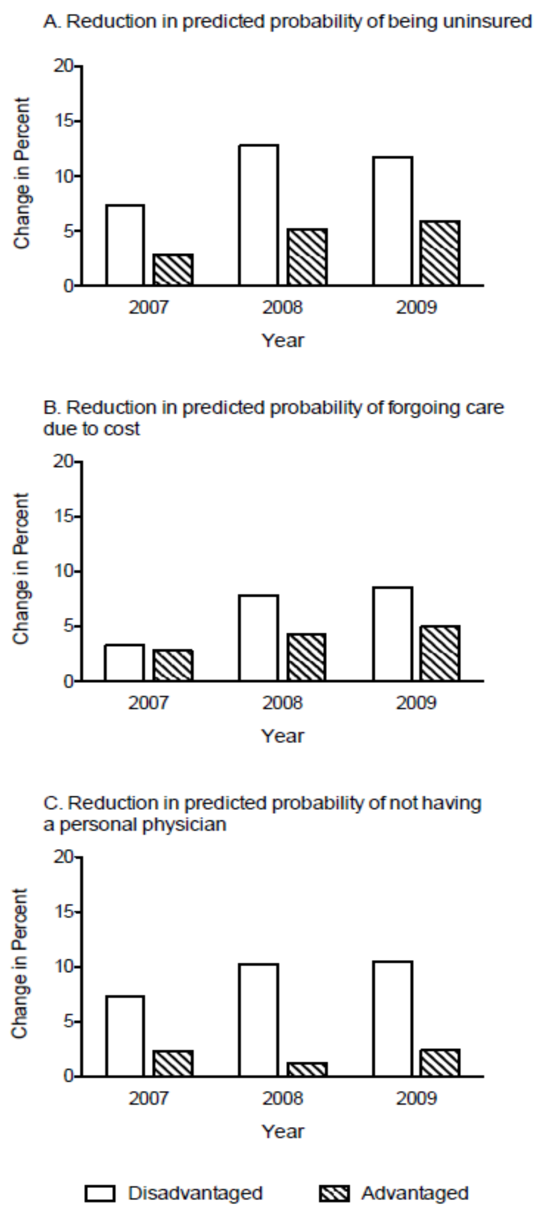
In absolute terms, improvements in the disadvantaged group were greater for all three outcomes in all three-post reform years (Figure 2). However, the relative change in effect size between the disadvantaged and advantaged groups were non-significant in adjusted time series models for all three outcomes in all three post-reform years (results not shown).

**Sensitivity Analyses**

To consider the possibility of bias resulting from other changes unique to MA during the reform period, a parallel analysis among the Medicare-eligible population in MA and the control states (n=48,224) was conducted. No significant differences were found in the probabilities of forgoing care due to cost or not having a personal physician, suggesting that the main findings in non-elderly adults were not contaminated by other factors. The Medicare-eligible population in MA did have a significantly lower rate of uninsurance than the corresponding population in the control states after the reforms. This is to be expected as before the reforms the uninsured elderly population in MA was mostly low income (71 per cent earned less than $25,000 annually) or Hispanic (18 per cent) -- both groups targeted by the reforms.

**Figure 2**

Estimated effect of Massachusetts reform on study outcomes in disadvantaged and advantaged groups showing a greater absolute effect of the reform in disadvantaged groups. All estimates control for household size, employment, age, sex, and marital status. Estimates for the disadvantaged group also control for race, income and education as they vary within this sub-population.



Examining the robustness of the results, neither direction nor magnitude of effects changed substantially when any one comparison state was excluded. Alternate model specifications resulted in effects within the confidence intervals of the effect sizes in the original model, indicating that the original specification was robust. As expected, the model that assumed post-reform trends to be linear estimated smaller changes in outcomes in 2008 and larger changes in 2009. The model that assumed similar pre-reform trends in MA and comparison states estimated somewhat smaller effects of the reform and was more sensitive to outliers.

## Discussion

Our analyses revealed three important findings. MA health reforms had large and statistically significant overall effects in reducing rates of uninsurance, reducing the likelihood of forgoing care due to cost, and improving access to a personal physician. However, the positive effects of the reform attenuated from 2008 to 2009. This is consistent with other analyses, which have attributed this result to the global economic crisis.[11] It may also indicate reduced impact of the reform over time. Future studies should monitor longer-term effects, especially on final health outcomes that cannot be assessed in such a short period. Finally, the reforms had a greater absolute effect among disadvantaged groups, although the relative differences compared to advantaged groups were not significant. This may be due to the disadvantaged group having substantially worse outcomes at baseline and greater scope for improvement.

Our observation of increased access to personal physicians in MA after the reforms is especially relevant. Anecdotal evidence suggested that it might be more difficult to find a personal physician due to the numbers of newly insured MA residents.[20] Surveys of physician wait times in MA have pointed to long waits but changes since the reform were unclear.[22] However, neither of these studies used pre-reform data as a comparison.

Our study has substantial application to the ongoing national debates over health reform. The federal health reform and the MA reform are similar in use of health insurance mandates, health insurance exchanges, and expansion of coverage. This may suggest significant national gains in coverage and access due to the implementation of the PPACA.[22] A recent analysis of the MA reforms suggested that mandating health care was responsible for an increase in enrollment of healthy individuals as compared to when healthcare was subsized.[13]

However, the implementation of the national reform could differ substantively. The MA reforms were passed with virtually universal support; there were only two dissenting votes in both houses of the legislature.[22] This allowed public officials to embark on a widespread social marketing campaign which could have been responsible for the acceptance and success of the mandate. The experience with national reform has been markedly different, with implementation of the mandate producing polarizing debate and inspiring organized resistance. The penalties for non-compliance with the insurance mandate in the national reform ($695 per person to a maximum of $2085 per family) are also three to four times higher than in MA ($218 for an individual and

$437 for a family in 2007), which could imply different quantitative effects of the reforms at the national level.

The study contrasts with prior studies in several ways. A stronger quasi-experimental design and more recent data to estimate the effect of the MA reform were used.[8,10,11, 13,14, 23] The design accounts for pre-existing trends in MA and control states since the sensitivity analysis and the literature suggests that MA may have had unique factors leading up to the reforms[15]. The assumptions were validated by testing if the reforms had an effect in the group with Medicare eligibility; we found few significant differences between MA and control states in this over-65 population, which supports the inference about the effects of the reform. Similar to other work, we demonstrate that the MA reforms had a significant effect overall in improving coverage and health access. However, unlike other studies, we demonstrate that the reform had a significant absolute effect among disadvantaged groups. Because racial and economic disadvantage often overlap, the subgroup analysis pooled traditionally disadvantaged racial and socioeconomic groups.

A number of limitations should be noted. The interrupted time series model has seven data points. Short time series are useful for causal inference as extra baseline data addresses threats to internal validity; extra post-intervention observations indicate persistence of the impact; and use of comparison groups strengthens inference. [16] While one of the control states, Vermont, introduced a limited set of health reforms concurrently,[24] the sensitivity analysis excluding Vermont showed no significant difference in results.

The use of BRFSS data could also limit external validity. Median response rates in all years of analysis ranged from 72 to 77 percent. The CASRO response rates were lower, ranging from 35 to 63 percent cent across states.[25] Changes in non-response over time could bias results; however, non-reponse biases in random-digit dialing (RDD) telephone surveys are probably modest,[26,27] and the use of sampling weights partially corrects for non-response bias. Since data were obtained by self-report, recall and other potential biases may also be relevant. The rise of cell phones and increase in call screening may be responsible for falling response rates in RDD surveys.[28,29] However, compared to mail-based surveys, RDD surveys have been found to be representative, cost-effective, and useful for contacting non-English speaking households (who are more likely to be uninsured).[30]

In summary, the results from Massachusetts provide strong evidence on the effectiveness of a package of health care reforms, including an individual mandate, in increasing access to health care, especially for disadvantaged groups. This is important to consider as implementation of the federal health reform and potential repeal of the mandate are debated.

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# Chapter 2:

## Are there gender disparities in access to medicines in low and middle income countries? Evidence from WHO household medicines surveys in five sub-Saharan African countries[b]

[b] This chapter is co-authored by Catherine E. Vialle-Valentin, Robert F. LeCates, Dennis Ross-Degnan, Anita K. Wagner

## Abstract

**Objective**

Equitable access to medicines is critical for effective health care. Gender disparities in medicines access are widely assumed, but few empirical studies have tested this hypothesis.

**Methods**

We analyzed data from the WHO and Medicines Transparency Alliance (MeTA) Household Medicines Surveys, completed in Gambia, Ghana, Kenya, Nigeria and Uganda in 2007-2008 (n=5,161). We formulated a novel seven-stage access to medicines pathway along which we systematically assessed gender disparities. In addition, we used multinomial logistic regression models to operationalize the Institute of Medicine (IOM) definition of disparity in a step wise manner and examined gender relationships with source of care, source of prescriptions, and source of obtaining medicines.

**Findings**

We observed significant gender differences in fewer than 10 per cent of unadjusted outcomes, with boys (under age 5) more likely to receive prescriptions from doctors or nurses and girls from more informal sources of care. No other significant gender differences were seen in health seeking behavior, sources of care, numbers or cost of medicines, or adherence, for either adults or children. Controlling for health status and country characteristics, there were no significant gender disparities in source of care, prescriptions, and medicines.

**Conclusion**

We found little evidence of gender disparities in access to medicines in five Sub-Saharan African countries. Our findings are consistent with emerging research across other developing countries and underline the need for generating country and subject specific evidence to appropriately target interventions toward equity in health care.

## Introduction

Access to medicines is crucial for effective health care and an important component of the realization of health as a human right.[1,2,3] Give equal need, if gender is the basis for differential access to medicines, [4,5] this would prevent the realization of WHO's goal of "health for all". While disparities in access to medicines due to gender in low- and middle-income countries have been hypothesized,[6,7] empirical evidence is lacking. Novel data from the only medicines-focused household survey to date, implemented by WHO and the Medicines Transparency Alliance (MeTA),[8] now make it possible to examine gender differences at different steps in the access to medicines pathway.

Poor access to medicines in the public sector, and high out-of-pocket spending for medicines in the private sector contribute significantly to impoverishment of the poor and near-poor. [9, 10] However, studies on gender disparities in access to medicines are few and inconclusive. In high-income countries (North America, Europe, Australia), research suggests greater use and spending on prescription medicines and greater prevalence of self-medication among women than men. [11,12] While these differences could be due to biological factors such as unique reproductive roles and longer life expectancies of women, they could also be explained by gender differences in perceptions of ill health, inclination to consult a medical doctor, and prescribing patterns.[6]

In low and middle income countries (LMIC), the link between gender and access to medicines is unclear. It is hypothesized that prevailing gender norms -- women's lack of resources, lack of participation in household decision making processes, values and norms that exclude or restrict women's participation in society, and legal constraints that favor men [13] -- may disadvantage women and result in them using fewer medicines. [6,14] Qualitative studies of access to tuberculosis treatment in Vietnam show that women delay care-seeking due to social stigma.[15] However, female patients with HIV infection in LMICs were at least as likely as men to start anti-retroviral therapy, possibly due to HIV counseling and testing in reproductive care settings.[16, 17]

Using newly available WHO data, we employed a structured empirical approach, asking three questions. First, are there gender disparities in different stages of the access to medicines pathway in African countries? Second, are gender disparities evident among people with chronic or acute illness? Third, does the relationship between gender and medicines access differ between poor and less poor individuals?

We formulated a novel access to medicines pathway, drawing on the Health Access Livelihood Framework [18] and the BASICS Pathway to Survival [19] to define seven steps where gender differences might occur, namely: symptoms are recognized, treatment is sought, care is accessible, medicines are available, medicines are affordable, medicines are acceptable, and medicines are taken as needed (Figure 3). We applied the Institute of Medicine (IOM) definition of disparities in which gender differences due to the health care system or its legal and regulatory environments are considered disparities or unjust differences, while differences due to health care needs or preferences are not. [20] In the IOM construct clinical needs are appropriate, while

**Figure 3: Access to medicines pathway: Incident illness to medicines access**

| Steps Towards Medicines Access | Categories of Outcome Measures* |
|---|---|
| 1. Symptoms are recognized | • Acute conditions reported<br>• Chronic conditions reported |
| 2. Care is sought | • Treatment sought (acute only) |
| 3. Care is accessible | • Advised to take medicines/took medicines<br>• Sources where care was sought (acute only) |
| 4. Medicines are available | • Number of medicines taken<br>• Source of prescriptions (acute only)<br>• Source of medicines (acute only) |
| 5. Medicines are affordable | • Cost of medicines (full course for acute illness and monthly cost for chronic illness)<br>• Coverage of medicines by health insurance |
| 6. Medicines are acceptable | • Opinions on access to medicines<br>• Opinions on affordablity of medicines<br>• Opinions on quality of medicines |
| 7. Medicines regimens are adhered to | • Non-adherence<br>• Reasons for non-adherence |

*Unless specified, outcome measures refer to acute and chronic conditions.

differences in care due to patients' socioeconomic status (and correlates of socio-economic status such as education or household location) are unjustifiable and so are targets for improvements.[21,22] Inappropriately controlling for socioeconomic status or its correlates would cause underestimation of the magnitude of the gender effect on health.

## Methods

### Data Source

We analyzed cross-sectional data from the Medicines Transparency Alliance (MeTA) and WHO Household Medicines Survey conducted in Gambia, Ghana, Kenya, Nigeria, and Uganda.[8] Between 900 and 1080 households per country, selected based on stratified cluster sampling, completed the surveys between August 2007 and December 2008.[23,24]

The survey captured information on access to medicines for acute and chronic illnesses and opinions on medicines. In each household, one respondent was selected who was the main health care decision maker; designated caregiver for sick household members; or most knowledgeable about the health, health expenditures, or health care utilization of the household. The respondent reported on current chronic and recent acute illnesses for all household members and gave his or her opinions on access to, affordability, and quality of medicines. The survey collected socio-demographic data on age, gender, and education of household members, and on household income.

Two versions of the survey were administered. A long questionnaire, administered in Ghana, Kenya and Uganda, captured demographic information for each household member, and details on treatment for each household member who had an acute illness in the last two weeks or a current chronic disease. A short questionnaire, administered in Nigeria and Gambia, captured information on the youngest household member with an acute illness in the last two weeks and the oldest household member with a chronic illness. Since country specific sample sizes were too small for robust inferences, we pooled data from all five countries.

**Outcome Measures**

For each household member for whom the respondent reported a recent acute or current chronic illness, we constructed measures of symptom recognition and health seeking behavior. The resulting seventy-three indicators (binary or continuous) were classified according to a seven stage access to medicines pathway (Figure3 and Table 5):

**1. Symptom recognition**: Presence of sets of acute symptoms (cough, runny nose, sore throat, ear ache; fever, headache, hot body; diarrhea, vomiting, nausea, could not eat; pain and aches; other; yes/no) and chronic conditions (hypertension, high blood pressure; heart disease, heart attack, stroke, high cholesterol; diabetes, high blood sugar; asthma, wheezing, chronic difficulty breathing; HIV infection, AIDS; arthritis, chronic body pain; ulcer, chronic stomach pain; depression; other; yes/no).

**2. Care seeking**:  Individuals reporting an acute illness sought treatment outside their homes (yes/no).

**3. Accessibility of care and medicines**: Location where individuals sought care during their acute illness episode (public hospitals; public health center or dispensary; private hospital, clinic, physician, private pharmacy or drug seller; non-governmental organization (NGO) or mission hospital; other; more than one source of care; yes/no); and whether they took medicines for acute illness or had medicines recommended for chronic illnesses (yes/no).

**4. Availability of medicines**: Type of provider who prescribed medicines during the acute illness episode (doctor or nurse; pharmacist or drug seller; other; more than one provider; yes/no); and places where medicines were obtained (public hospital; public health center; private pharmacy or drug seller; private health provider, NGO or mission hospital; other; more than one source; yes/no). Total number of medicines taken for the recent acute illness and recommended for chronic illnesses.

**5. Affordability of medicines**: Total cost of medicines for treating the acute illness episode and for chronic conditions taken in the past month (in local currency). Partial or full coverage of any medicine for chronic illness by health insurance (yes/no).

**6. Acceptability of medicines**: Respondent's agreement with statements on accessibility, affordability and quality of medicines (yes/no).

**7. Adherence to medicine regimen**: Individuals having taken all medicines prescribed or recommended (yes/no) and agreement with reasons for not taking medicines (yes/no).

**Predictor Measures**

The primary predictor was the gender of the person reported to have had an acute or chronic condition. In multivariate models, based on the IOM framework of disparities we included health status and geographic variables.[23, 24, 28] Variables adjusting for socioeconomic status (SES) were explored in bivariate associations, but not included in multivariable modeling.

Health status variables were age (distribution based on survey design; five years and older versus under five years old for acute illness; 30 years and older versus under 30 years old for chronic conditions and 25 years and older versus under 25 years old for acceptability of medicines indicators) and self-reported severity of acute illness (very or somewhat serious, compared to not serious).

Geographic variables included binary measures for whether or not the household was less than one hour from: a public source of care (public hospital or public health center), a private source of care (private or NGO hospital), or a private pharmacy or drug seller.

SES variables were education, defined as whether or not the respondent (in Gambia and Nigeria) or patient (in Ghana, Kenya, Uganda) completed at least primary school or not, and household income, dichotomized as belonging to the first or second income quintile (poor) versus the remaining quintiles (relatively non-poor). Quintiles were calculated based on self-reported classification of monthly household expenditures, taking into consideration country and household size.

**Statistical Analysis**

The unit of analysis was the sick individual. Since health-seeking behavior may differ for acute and chronic conditions, we modeled acute and chronic conditions separately. Decisions to seek care could also differ for children versus adults, and some outcomes only applied to adults (chronic illness, opinions about treatment); we therefore modeled outcomes for children separately. We tested bivariate associations of the seventy-three outcomes in the access to medicines pathway with gender. We stratified each analysis into two age groups resulting in 146 tests of difference of means based on a t-distribution, conservatively conducted with unequal variances.[26]

Among patients with acute illnesses, we assessed previously hypothesized gender differences[6,7,13,27] in source of care, source of prescriptions, and source of medicines using hierarchical models with clustering at the household level. Covariates were selected based on the IOM definition of disparities, controlling for "justifiable differences" due to health status and geography.[21-25, 28] We used multinomial logistic regression models to estimate the adjusted risk ratio of seeking care or medicines at a given source. We also tested interactions of gender with age, income, and education as these variables could have potential moderating effects on the relationship between gender and access to medicines.

All analyses were performed using Stata 10.0 (StataCorp, Texas) and results were considered significant if $p \leq 0.05$.

## Results

### Sample Description

The sample consisted of 19,116 individuals in 5,161 households across five countries. 2,880 individuals had a recent acute illness and 1,254 reported chronic illnesses (Table 3).

More than half (55 per cent) of household members with recent acute illnesses or chronic illness were female. Men and women lived at similar distances from sources of care. Among patients with acute illness, men were significantly younger (mean age 13 versus 16 years) and poorer than women (proportion in the first two quintiles 62 per cent versus 58 per cent; Table 4). Among patients reporting chronic illness, men were significantly more likely to have completed primary school education (69 per cent versus 52 per cent).

**Table 3: Country samples**

| | Gambia* | Ghana | Kenya | Nigeria* | Uganda | Total |
|---|---|---|---|---|---|---|
| Households (N) | 900 | 1065 | 1065 | 1080 | 1051 | 5161 |
| Individuals (n) | 900 | 5360 | 5853 | 1080 | 5923 | 19,116 |
| Individuals reporting recent acute illness | 553 | 317 | 674 | 610 | 726 | 2880 |
| Individuals reporting recent chronic illness | 176 | 166 | 300 | 290 | 322 | 1254 |

* In Gambia and Nigeria, the short form of the survey was used which only collected limited demographic data from the respondent for each household. Data on acute illness was collected only for the youngest household member with acute illness and chronic illness for the oldest household member with chronic illness. In Ghana, Kenya, and Uganda, the long form of the survey was used which collected information on all household members with acute and chronic illnesses.

## Unadjusted differences

There were few unadjusted differences by gender. Across 146 outcomes representing the seven stages of access to medicines pathway for two age categories, we found significant gender differences in less than 10 per cent (12 outcomes; Table 5). Standard errors for approximately 80 per cent of the 146 outcomes were less than 5 per cent with many less than 1 per cent.

## 1. Symptom recognition

Girls and women over five years were significantly more likely than boys and men to report pain and aches and women under thirty were more likely to report heart conditions. Men over thirty

| **Table 4: Patient characteristics** | **Acute Illness** | | **Chronic Illness** | |
|---|---|---|---|---|
| | **Male** | **Female** | **Male** | **Female** |
| ***Health Status*** | (n= 1295) | (n=1585) | (n= 556) | (n=698) |
| Age (mean; years) | 13.1* | 16.3* | 46.5 | 44.8 |
| Severity of acute illness (%) | | | | |
| Very serious | 10.0 | 11.8 | n/a | n/a |
| Somewhat serious | 22.2 | 28.1 | n/a | n/a |
| Not serious | 12.8 | 14.7 | n/a | n/a |
| ***Country (%)*** | | | | |
| Gambia | 18.8 | 19.6 | 11.9* | 15.8* |
| Ghana | 8.8* | 12.8* | 9.9* | 15.9* |
| Kenya | 22.4 | 24.2 | 24.5* | 23.5* |
| Nigeria | 24.4* | 18.5* | 29.5* | 18.1* |
| Uganda | 25.6 | 24.9 | 24.3 | 26.8 |
| ***Geography (%)*** | | | | |
| Distance from private source of care less than 1 hour | 35.3 | 32.8 | 39.6 | 36.3 |
| Distance from public source of care less than 1 hour | 40.5 | 39.3 | 42.9 | 41.3 |
| Distance from pharmacy or drug seller less than 1 hour | 47.4 | 49.1 | 51.0 | 51.9 |
| ***Socio economic status (%)*** | | | | |
| Completed primary school[+] | 54.6 | 53.1 | 58.9* | 51.6* |
| Poor (monthly income in quintile 1 or 2) | 61.5* | 57.9* | 53.0 | 57.9 |
| ** differ at p<.05* | | | | |

[+] For long surveys (Ghana, Kenya, Uganda), education level is that of the patient. For short surveys (Gambia, Nigeria), education level is that of the household head.

were significantly more likely to report diabetes or high blood sugar, while men under thirty were more likely to report other chronic conditions. Both genders reported all other acute symptoms and chronic conditions with similar frequency.

## 2. Care seeking

There were no significant gender differences in care seeking outside the home by age group for acute illness. All groups sought care approximately 90 per cent of the time.

## 3. Care seeking behavior and medicines

There were no significant gender differences by age group in medicines taken for acute symptoms or recommended for chronic conditions, or in source of care for acute illnesses. In analyses across all age groups, we found men more likely than women to seek care for acute illnesses at public hospitals (22.6 per cent men as compared to 19.1 per cent women; results not shown).

## 4. Availability of medicines

Boys under age five were more likely to receive prescriptions for acute conditions from a doctor or nurse while girls of the same age were more likely to receive prescriptions from other sources of care (self, household member, friend, neighbor, or traditional healer). Men and women of the same age took similar numbers of medicines for acute symptoms and obtained medicines with equal frequency from the same sources.

### 5. Affordability of medicines

Women under 30 years of age in Kenya spent more money on chronic medicines. There were no significant gender differences in total payment for acute care medicines or in reported monthly costs of chronic illness medicines by country. There was also no significant gender difference in insurance coverage for chronic illness; however, men under 30 years of age reported insurance coverage for any chronic care medicine half as often as women.

### 6. Acceptability of medicines

There were some significant gender differences in opinions about medicines. Women reported higher likelihood of finding needed medicines in the private pharmacy near their house and of obtaining prescribed medicines if insurance reimbursed part of the cost. Men were more likely to report that in the past their household had to borrow money or sell household possessions to pay for medicines and that they believed imported medicines were of better quality than locally manufactured ones. There were no significant gender differences in opinions about the affordability, quality, and accessibility of medicines.

### 7. Adherence to medicine regimens

There were no gender differences in reported adherence or reasons for non-adherence for acute or chronic medicines by age group. Reported adherence rates ranged from 84 to 87 per cent.

**Adjusted models of disparities**

There were no significant gender differences in source of care, prescriptions, and medicines when IOM concordant covariates (health status, country; results available on request) were included in the model (Figure 4; Web Appendix 6a-c). However, severity of illness, age, and country were significant predictors in some models.

**Are poor women differentially affected? Modification by Age, Income or Education**

In regression models, patient age, household income, and respondent completion of primary school education were significantly associated with source of acute care, of prescriptions, and of medicines, but these variables did not moderate the association between gender and source of acute care, prescriptions, and medicines (interaction terms not statistically significant; results available on request).

## Table 5: Outcomes along the access to medicines pathway by gender and age

| Outcomes | Male | Female | Male | Female |
|---|---|---|---|---|
| **1) Symptom recognition** | **Under 5 years** | | **5 years and over** | |
| a) Acute conditions | *(n=622)* | *(n=568)* | *(n=667)* | *(n=1012)* |
| i) Cough, runny nose, sore throat, ear ache | 39.4% | 43.5% | 32.8% | 33.4% |
| ii) Fever, headache, hot body | 74.3% | 72.7% | 66.1% | 65.1% |
| iii) Diarrhea, vomiting, nausea, could not eat | 26.8% | 30.6% | 21.3% | 20.3% |
| iv) Pain, aches | 15.0% | 17.1% | **28.6%*** | **34.9%*** |
| v) Other[c] | 30.9% | 26.1% | 32.8% | 31.5% |
| | **Under 30 years** | | **30 years and over** | |
| b) Chronic conditions | *(n=124)* | *(n=162)* | *(n=429)* | *(n=534)* |
| i) Hypertension, high blood pressure | 4.0% | 8.0% | 42.2% | 47.4% |
| ii) Heart disease, heart attack, stroke, high cholesterol | **0%*** | **4.3%*** | 7.7% | 6.9% |
| iii) Diabetes, high blood sugar | 3.2% | 3.7% | **18.2%*** | **11.8%*** |
| iv) Asthma, wheezing, chronic difficulty breathing | 28.2% | 25.3% | 11.0% | 11.0% |
| v) HIV infection, AIDS | 7.3% | 8.6% | 7.2% | 8.1% |
| vi) Arthritis, chronic body pain | 6.5% | 5.6% | 17.2% | 21.2% |
| vii) Ulcer, chronic stomach pain | 12.9% | 20.4% | 16.8% | 20.8% |
| viii) Depression | 2.4 | 2.5 | 2.6 | 3.2 |
| ix) Other[d] | **46.4%*** | **34.6%*** | 12.1% | 10.8% |
| **2) Care seeking** | **Under 5 years** | | **5 years and over** | |
| | *(n=622)* | *(n=568)* | *(n=667)* | *(n=1012)* |

[c] Other acute conditions included difficulty breathing, fast breathing; convulsions, fits; could not sleep; thirst, sweating; or bleeding, burn, accident.

[d] Other chronic conditions include cancer, epilepsy, seizures, fits, tuberculosis, liver disease

**Table 5 (continued)**

| Outcomes | Male | Female | Male | Female |
|---|---|---|---|---|
| a) Care sought outside the home | 91.2% | 91.2% | 90.5% | 90.1% |
| **3) Accessibility of c and medicines** | **Under 30 years** | | **30 years and over** | |
| a) Medicine recommended for chronic disease | *(n=124)* 89.5% | *(n=162)* 89.5% | *(n=429)* 92.0% | *(n=534)* 92.2% |
| | **Under 5 years** | | **5 years and over** | |
| b) Medicine taken during acute illness | 94.4% | 95.6% | 94.8% | 94.8 |
| c) Sources of care for acute illness | *(n=489)* | *(n=448)* | *(n=534)* | *(n=803)* |
| i) Public hospital | 24.1% | 19.9% | 21.2% | 18.6% |
| ii) Public health center or dispensary | 37.6% | 40.0% | 32.2% | 34.0% |
| iii) Private hospital, clinic or physician | 12.1% | 12.5% | 14.2% | 14.9% |
| iv) Private pharmacy or drug seller | 17.4% | 20.3% | 21.9% | 20.9% |
| v) NGO, mission hospital | 7.4% | 6.0% | 7.9% | 9.3% |
| vi) Other (traditional healer, friend, neighbor) | 1.4% | 1.3% | 2.6% | 2.2% |
| vii) More than one source of care | 13.9% | 13.0% | 11.6% | 11.6% |
| **4) Availability of medicines** | **Under 5 years** | | **5 years and over** | |
| a) Number of medicines for acute illness (mean) | 2.7 | 2.7 | 2.4 | 2.5 |
| b) Source of prescriptions for acute illness | *(n=563)* | *(n=515)* | *(n=592)* | *(n=907)* |
| i) Doctor, nurse | **56.1%*** | **48.9%*** | 59.0% | 61.5% |
| ii) Pharmacist or drug seller | 11.4% | 11.3% | 14.2% | 12.3% |
| iii) Other (self, household member, friend, neighbor, traditional healer) | **32.5%*** | **39.8%*** | 26.9% | 26.1% |
| iv) More than one source of prescribing | 3.4% | 3.6% | 3.6% | 3.7% |
| c) Source of medicines for acute illness | *(n=484)* | *(n=447)* | *(n=504)* | *(n=765)* |
| i) Public hospital | 19.3% | 15.6% | 15.8% | 14.8% |
| ii) Public health center | 35.3% | 38.8% | 29.5% | 31.9% |
| iii) Private pharmacy, drug seller | 32.1% | 34.9% | 42.0% | 40.4% |

**Table 5 (continued)**

| | | | | |
|---|---|---|---|---|
| iv) Private health provider | 10.3% | 9.4% | 13.2% | 13.2% |
| v) NGO, mission hospital | 8.8% | 6.6% | 8.1% | 8.7% |
| vi) Other (home, friend, neighbor, traditional healer) | 4.5% | 4.1% | 4.6% | 4.1% |
| vii) More than one source of medicines | 7.6% | 8.3% | 7.5% | 7.0% |
| | **Under 30 years** | | **30 years and over** | |
| d) Number of medicines for chronic illness (mean) | 1.7 | 1.7 | 2.0 | 2.0 |
| **5) Affordability of medicines** | | | | |
| a) Cost of all medicines for acute illness (local currency) | **Under 5 years** | | **5 years and over** | |
| i) Gambia (n=189) | 27.0 | 26.1 | 25.2 | 49.6 |
| ii) Ghana (n=205) | 3.1 | 13.2 | 5.5 | 39.9 |
| iii) Kenya (n=534) | 160.1 | 167.7 | 450.0 | 340.8 |
| iv) Nigeria (n=598) | 1103.3 | 1437.4 | 1408.2 | 1170.4 |
| v) Uganda (n=423) | 5219.0 | 3576.3 | 6766.1 | 4870.0 |
| b) Cost of all medicines for chronic illness (local currency) | **Under 30 years** | | **30 years and over** | |
| i) Gambia (n=86) | 14.2 | 7.0 | 94.6 | 10.2 |
| ii) Ghana (n=131) | 4.6 | 8.3 | 238.7 | 7.5 |
| iii) Kenya (n=156) | **38.8*** | **261.0*** | 444.0 | 277.8 |
| iv) Nigeria (n=187) | 823.7 | 591.7 | 1751.8 | 2276.1 |
| v) Uganda (n=132) | 2551.8 | 8558.6 | 14092.1 | 4092.7 |
| c) Cost covered by health insurance for at least one chronic illness medicine | 5.0% | 11.4% | 10.7% | 11.8% |
| **6) Acceptability of medicines (% agreeing)** | **Under 25 years** | | **25 years and over** | |
| a) Opinions on access | *(n=108)* | *(n=278)* | *(n=2402)* | *(n=2102)* |
| i) The public health facility closest to my household is easy to reach | 75.9% | 72.3% | 68.3% | 69.7% |
| ii) My household would use public health facilities more if the opening hours were convenient | 79.6% | 75.8% | 76.6% | 74.3% |
| iii) The public health facility closest to my house usually has the medicines we need | 42.6% | 40.6% | 37.9% | 39.0% |

**Table 5 (continued)**

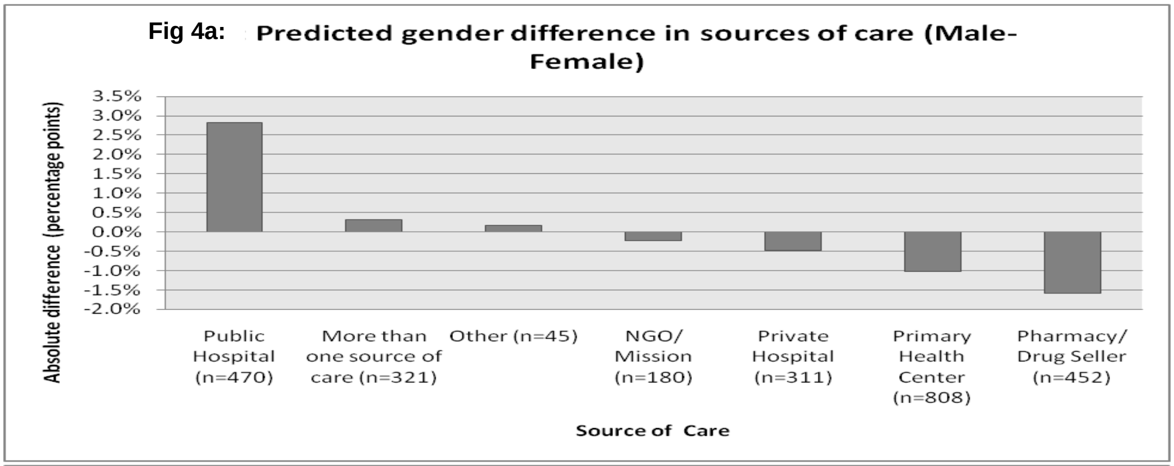
| | | | | |
|---|---|---|---|---|
| iv) The private pharmacy closest to my household has the medicines my household needs | 60.2% | 65.3% | **59.7%*** | **63.3%*** |
| b) Opinions on affordability | **Under 25 years** | | **25 years and over** | |
| i) My household can get free medicines at the public health care facility | 59.2% | 63.5% | 49.6% | 50.5% |
| ii) Medicines are more expensive at the private pharmacies than at public health care facilities | 75.0% | 74.5% | 75.2% | 75.1% |
| iii) My household can usually get credit from the private pharmacy if we need to | 15.7% | 21.2% | 22.0% | 19.7% |
| iv) My household can usually afford to buy the medicines we need | 52.8% | 49.8% | 46.8% | 47.6% |
| v) My household would obtain prescribed medicines if insurance reimbursed part of the cost | 41.7% | 40.8% | **36.2%*** | **43.0*** |
| vi) In the past, my household had to borrow money or sell things for medicines | 50.0% | 46.4% | **49.4%*** | **44.9%*** |
| c) Opinions on quality | **Under 25 years** | | **25 years and over** | |
| i) The quality of services delivered at public health facilities in my neighborhood is good | 62.6% | 61.4% | 63.5% | 62.5% |
| ii) The quality of services delivered by private health care providers in my neighborhood is good | 71.0% | 73.1% | 65.7% | 67.9% |
| iii) Imported medicines are of better quality than locally manufactured ones | 38.8% | 34.6% | **36.7*** | **33.4*** |
| **7) Adherence to medicine regimens (% respondents agreeing)** | **Under 5 years** | | **5 years and over** | |
| a) Sick person took all medicines recommended or prescribed for acute illness | 86.7% | 84.4% | 84.5% | 83.5% |
| b) Reasons for not taking medicines | *(n=111)* | *(n=99)* | *(n=149)* | *(n=244)* |
| i) Symptoms have gotten better | 45.0% | 57.6% | 38.3% | 35.7% |
| ii) Someone in the household decided that medicines were not needed/ advised not to take/ chose a different treatment | 16.2% | 12.1% | 9.4% | 10.2% |
| iii) Sick person had bad reactions to medicines in the past | 0.9% | 3.0% | 4.0% | 3.3% |
| iv) The place where medicines can be obtained was too far away/ medicines were not available at public health facility/ not available at pharmacy/ no one had time to obtain medicines | 18.0% | 17.2% | 8.1% | 9.8% |
| v) Our household could not afford medicines | 11.7% | 14.1% | 7.4% | 9.0% |
| | **Under 30 years** | | **30 years and over** | |
| c) Sick person took all medicines recommended or prescribed for chronic illness | 88.5% | 84.9% | 87.8% | 85.5% |
| d) Reasons for not taking medicines | *(n=12)* | *(n=22)* | *(n=49)* | *(n=72)* |

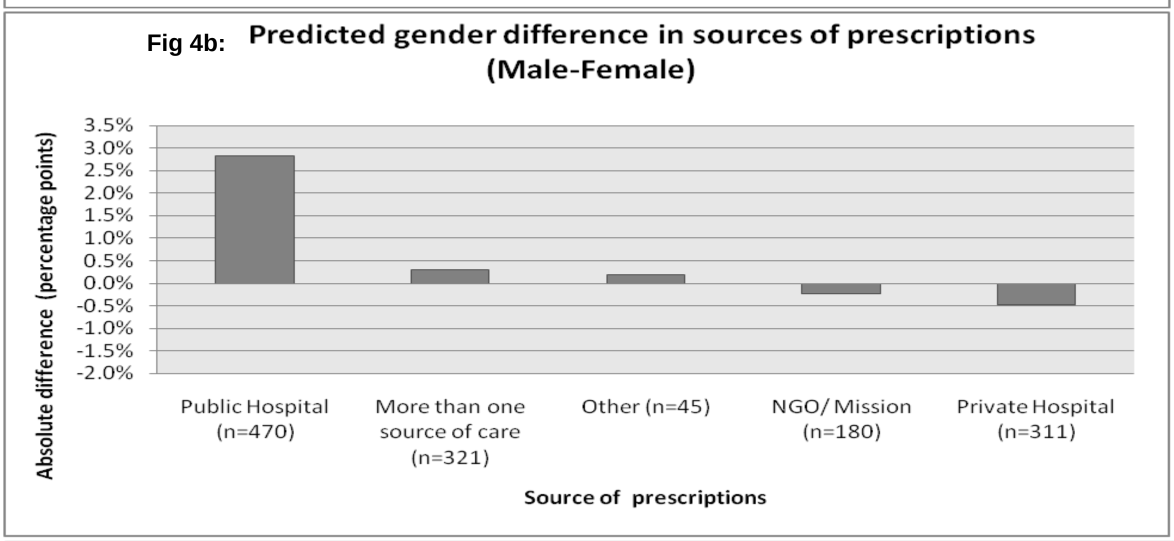
**Table 5 (continued)**

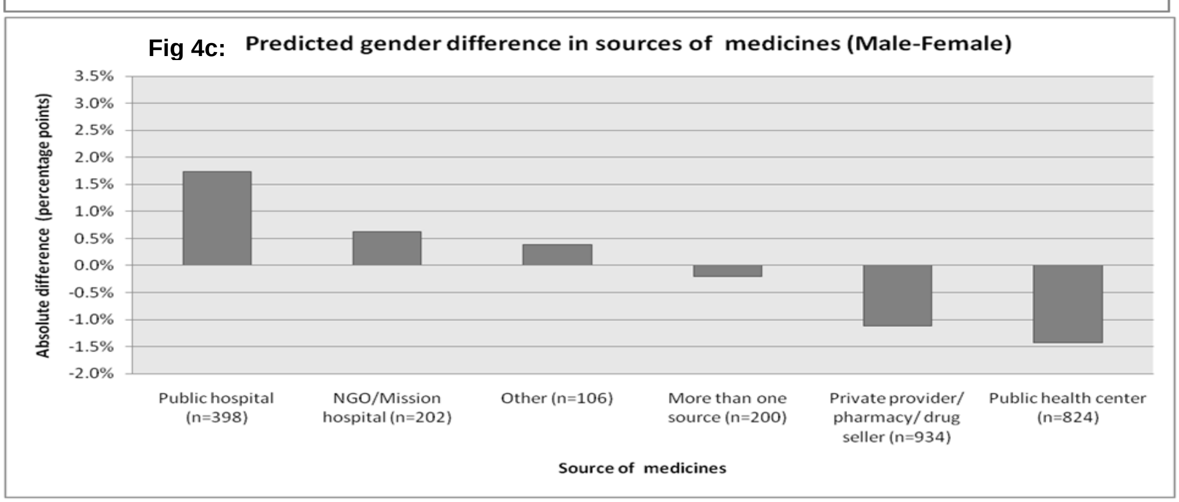
| | | | | | |
|---|---|---|---|---|---|
| i) | Symptoms have gotten better | 50.0% | 50.0% | 49.0% | 41.7% |
| ii) | Someone in the household decided that medicines were not needed/ advised not to take/ chose a different treatment | 25.0% | 31.8% | 20.4% | 18.1% |
| iii) | Sick person had bad reactions to medicines in the past | 16.7% | 0.0% | 8.2% | 15.3% |
| iv) | The place where medicines can be obtained was too far away/ medicines were not available at public health facility/ not available at pharmacy/ no one had time to obtain medicines | 25.0% | 31.8% | 38.8% | 38.9% |
| v) | Our household could not afford medicines | 16.7% | 18.2% | 34.7% | 29.2% |

**Figure 4: Predicted gender differences in medicines access outcomes for acute illness**

(shows trends, though no difference is statistically significant)



## Discussion

Our research has several unique contributions. We offer one of the few methodologically rigorous cross-country evaluations of the widely-held belief that gender disparities disadvantaging women extend to all aspects of health care, including medicines access. The unexpected result adds much-needed evidence to the discourse about gender inequities in medicines access in LMIC. In addition, we are among the first to operationalize the Institute of Medicines definition of disparities in the study of access to medicines. [28,29,15]

We did not find hypothesized inequities in medicines access disadvantaging women in LMICs.[6] Emerging evidence from 2002 WHO World Health Survey data in 53 countries and IMS prescribing data in 15 mostly LMICs also suggest that women generally have similar access to medicines as men, when controlling for health care need.[30,31] We also found no significant differences in medicines access for boys and girls, consistent with results from a recent study in rural Bangladesh which reported no differences in prevalence of illness or care-seeking pattern for children [32] and a UNICEF report [33] showing that treatment for childhood pneumonia, diarrhea, and malaria did not vary by gender.

Two synergistic mechanisms may explain these findings. Concepts of “masculinity” may make it unacceptable for men to seek care and medicines.[34,35] In addition, women may have enhanced access to acute and chronic care medicines through reproductive and child health services in primary health settings.[36,37]

Our study has some limitations. Respondents reported outcomes on behalf of ill household members. If they remembered events differently for men and women, recall bias could have affected our results. By confining reports of acute illness to the previous two weeks, the survey attempted to minimize recall bias. The validity of the self-reported measure of household expenditures is unknown. Differential misclassification of expenditures by patient gender, however unlikely, might have impacted our multivariate results.

Sample size for some of the subgroup analyses (e.g. cost of medicines in each country, reasons for non-adherence) was limited and our analyses may have lacked power to detect gender differences for certain outcomes. However, nearly 80 per cent of our outcomes had standard errors less than 5 percent. Given the large number of outcomes, we performed multiple statistical tests. Adjusting for multiple testing could only have decreased the number of statistically significant findings, adding confidence to our overall finding of few gender-related differences.

Our study was based on data from a dedicated medicines survey in five Anglophone countries in Sub-Saharan Africa. The sampling methodology makes results representative for the population that lives within fifteen kilometers of a hospital or primary health care facility, but not necessarily for more remote populations. Since gender norms are thought to vary by region and culture, we cannot necessarily generalize findings beyond the study countries. To account for country differences, we included country-specific fixed effects in our models.

Although we did not find gender inequities in the outcomes measured, they may exist in these or other populations. For example, women may receive different types of medicines, or may receive medicines later in the course of illness, requiring studies of gender equity in quality of care. Also, while men and women paid approximately the same amount for medicines, women may have experienced the economic burden of or negotiating for medicines payment differently. Although the study countries varied widely on the 2010 Global Gender Gap Index with Uganda rated more (33 of 134 countries) and Nigeria less (118) equitable,[38] gender dynamics in Africa are likely different from those in Asia where studies have shown differences in access to medicines.[39,40, 41]

Our findings have recommendations directly applicable to other LMICs. To ensure efficient and effective use of resources, policy makers, and leaders of gender mainstreaming programs should use evidence to parse out exactly where disparities may occur and focus resources on these bottlenecks. The seven-stage access to medicines pathway proposed in our study may serve to identify, target, and evaluate potential gender and socioeconomic disparities in medicines. Disparities in one aspect of health seeking may not necessarily apply to others.

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| Web Appendix Table 6a: Risk Ratios (95% CI) from multivariable models predicting source of acute care[1] | | | | | | |
|---|---|---|---|---|---|---|
| | **Public Hospital** | **Private Hospital** | **Pharmacy or drug seller** | **NGO, mission hospital** | **Other[2]** | **More than one source of care** |
| | *(n=470)* | *(n=311)* | *(n=462)* | *(n=180)* | *(n=45)* | *(n=321)* |
| Being female | 0.83 | 1.01 | 1.06 | 1.00 | 0.88 | 0.95 |
| | (0.64-1.07) | (0.75-1.38) | (0.81-1.39) | (0.72-1.39) | (0.49-1.56) | (0.73-1.23) |
| Very serious illness[3] | 2.59* | 1.83* | 0.28* | 2.64* | 3.43* | 2.05* |
| | (1.85-3.63) | (1.17-2.9) | (0.19-0.41) | (1.55-4.49) | (1.26-9.35) | (1.42-2.95) |
| Somewhat serious illness[3] | 1.38+ | 1.18 | 0.44* | 1.79* | 1.90 | 1.38+ |
| | (0.98-1.93) | (0.83-1.67) | (0.32-0.59) | (1.11-2.87) | (0.77-4.71) | (0.97-1.97) |
| Being over five years of age | 1.18 | 1.01 | 1.41* | 1.50* | 2.15* | 1.13 |
| | (0.91-1.53) | (0.77-1.34) | (1.05-1.89) | (1.04-2.17) | (1.02-4.52) | (0.85-1.49) |
| Gambia[4] | 0.07* | 0.05* | 0.09* | 0.34* | 0.48 | 0.33* |
| | (0.04-.011) | (0.02-0.13) | (0.05-0.15) | (0.16-0.70) | (0.10-2.35) | (0.20-0.55) |
| Kenya[4] | 0.19* | 0.84 | 0.33* | 0.72 | 1.61 | 0.45* |
| | (0.13-0.29) | (0.44-1.6) | (0.20-0.55) | (0.35-1.47) | (0.36-7.16) | (0.27-0.77) |
| Nigeria[4] | 1.50+ | 0.85 | 1.90* | 1.34 | 5.41* | 2.55* |
| | (0.95-2.37) | (0.42-1.72) | (1.16-3.13) | (0.60-2.97) | (1.26-23.3) | (1.44-4.54) |
| Uganda[4] | 0.10* | 0.91 | 0.18* | 0.28* | 0.83 | 0.38* |
| | (0.06-0.15) | (0.49-1.67) | (0.11-0.28) | (0.12-0.61) | (0.18-3.88) | (0.22-0.66) |
| | | | | | | |

*p<.05 + p<.10

[1] Comparison group in models is public health center or dispensary (n=808)

[2] Other includes traditional healer, friend, and neighbor

[3] Compared to not serious

[4] Compared to Ghana

| **Web Appendix Table 6b. Risk Ratios (95% CI) from multivariable models predicting source of obtaining prescriptions for acute conditions**[1] | | | |
|---|---|---|---|
| | **Pharmacy or drug seller** | **Other**[2] | **More than one source of care** |
| | *(n=319)* | *(n=284)* | *(n=96)* |
| Being female | 0.97 | 1.09 | 1.09 |
| | (0.74-1.26) | (0.87-1.36) | (0.72-1.67) |
| Very serious acute illness[3] | 0.20* | 0.27* | 0.73 |
| | (0.14-0.29) | (0.19-0.37) | (0.40-1.33) |
| Somewhat serious acute illness[3] | 0.45* | 0.47* | 0.63+ |
| | (0.34-0.59) | (0.36-0.62) | (0.37-1.09) |
| Being over five years of age | 1.28+ | 1.06 | 1.22 |
| | (0.97-1.68) | (0.84-1.35) | (0.75-1.99) |
| Gambia[4] | 2.21* | 43.00* | 2.01 |
| | (1.18-4.15) | (26.60-69.46) | (0.75-5.34) |
| Kenya[4] | 0.57* | 1.16 | 0.70 |
| | (0.34-0.94) | (0.76-1.79) | (0.35-1.39) |
| Nigeria[4] | 1.71* | 2.03* | 1.69 |
| | (1.09-2.71) | (1.37-3.01) | (0.84-3.42) |
| Uganda[4] | 0.49* | 0.80 | 0.47* |
| | (0.29-0.81) | (0.51-1.28) | (0.22-1.00) |

*p<.05
+ p<.10
[1] Comparison group in models is doctor or nurse (n=1,476)
[2] Other includes self, household member, friend, neighbor, traditional healer
[3] Compared to not serious
[4] Compared to Ghana

| **Web Appendix Table 6c. Risk Ratios (95% CI) from multivariable models predicting source of obtaining medicines for acute conditions**[1] | | | | | |
|---|---|---|---|---|---|
| | **Public Health Center** | **Public Hosp** | **NGO, Mission Hospital** | **Other**[2] | **More than one source of care** |
| | *(n=824)* | *(n=398)* | *(n=202)* | *(n=106)* | *(n=200)* |
| Being female | 1.02 | 0.86 | 0.90 | 0.88 | 0.99 |
| | (0.81-1.29) | (0.66-1.12) | (0.63-1.23) | (0.55-1.41) | (0.73-1.34) |
| Very serious acute illness[3] | 1.42* | 3.31* | 3.32* | 1.36 | 2.56* |
| | (1.06-1.89) | (2.36-4.65) | (1.95-5.67) | (0.75-2.46) | (1.58-4.18) |
| Somewhat serious acute illness[3] | 1.55* | 1.86* | 2.12* | 1.14 | 1.45+ |
| | (1.19-2.02) | (1.35-2.56) | (1.42-3.16) | (0.73-1.79) | (0.95-2.19) |
| Being over five years of age | 0.73* | 0.90 | 0.95 | 0.81 | 0.84 |
| | (0.57-0.93) | (0.69-1.53) | (0.67-1.33) | (0.55-1.19) | (0.59-1.18) |
| Gambia[4] | 11.36* | 1.00 | 3.17* | 0.97 | 2.79* |
| | (7.11-18.16) | (0.66-1.53) | (1.80-5.61) | (0.39-2.38) | (1.56-4.98) |
| Kenya[4] | 1.45 | 0.26* | 0.88 | 0.83 | 0.88 |
| | (0.93-2.27) | (0.16-0.42) | (0.52-1.47) | (0.42-1.65) | (0.50-1.54) |
| Nigeria[4] | 0.35* | 0.81 | 0.52* | 0.71 | 0.95 |
| | (0.21-0.58) | (0.55-1.18) | (0.30-0.88) | (0.34-1.48) | (0.55-1.64) |
| Uganda[4] | 2.09* | 0.23* | 0.62 | 0.67 | 0.71 |
| | (1.40-3.12) | (0.14-0.37) | (0.34-1.11) | (0.34-1.33) | (0.40-1.26) |
| | | | | | |
| | | | | | |

*p<.05
+ p<.10

[1] Comparison group in models is private provider, pharmacy, or drug seller (n=934)
[2] Other includes home, friend, neighbor, and traditional healer
[3] Compared to not serious
[4] Compared to Ghana

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## Chapter 3:

## Disparities in quality and outcomes of care for patients with type 2 diabetes in Mexico City: Assessment of the impact of patient education using propensity score matching[e]

[e] This chapter is co-authored by Svetlana Duobova, Alan M. Zaslavsky, Joshua A. Salomon, Dennis RossDegnan, Ricardo Peres-Cuevas and Anita K. Wagner

## Abstract

### Background

Disparities in quality and outcomes of healthcare could be due to differences in patient educational attainment. Propensity score matching, allows us to more appropriately account for disparities compared to traditional unmatched regression based risk adjustments.

### Methods

Our sample included patients with type 2 diabetes who were older than 19 years of age and visited two family medicine clinics in Mexico City at least once in 2009 (n=13,855). The predictor variable of interest was education, categorized into three levels: illiterate and primary school (n=4,575); secondary and high school (n=3,856); undergraduate and postgraduate training (n=1,402). Outcomes were eleven indicators of processes of care and five indicators of clinical outcomes, defined based on existing guidelines for diabetes care. Adjusted differences between education and outcomes were calculated using Mahalanobis matching with calipers defined by propensity score and bootstrapped variances.

### Results

Unadjusted outcomes showed patients with higher education had better clinical outcome indicators than those with lower education. Propensity score matched estimates showed few significant differences in processes and outcomes of care, although the direction of estimates tended to indicate those with lower educational levels had better processes of care. The

unmatched regression based risk adjustments overestimated the significance and magnitude of the association.

**Conclusions**

Disparities by education on processes and outcomes of care are few when estimated based on propensity score methods and may be overestimated by unmatched regression methods. Characteristics other than education may be more important for targeting of programs to improve healthcare.

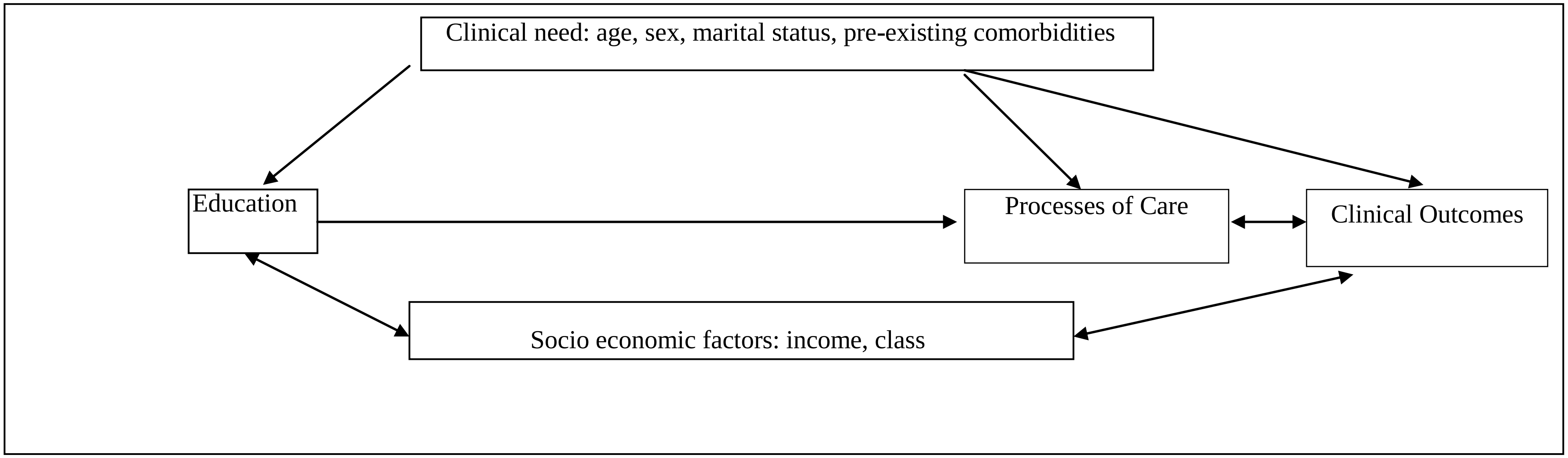
## Introduction

Understanding how disparities in healthcare processes may be associated with education is important to target interventions to improve quality of care and outcomes. However, it is challenging to determine the degree to which better education contributes directly to better health care and health; other factors associated with education and health care may also be important determinants of their relationship to health status (Figure 5).[1–6]

Education is one of the most stable indicators of socio economic status as it remains constant over a lifetime. Differences in health care by educational attainment do not necessarily imply disparities. As framed by the Institute of Medicine (IOM), disparities in health care can be defined as unfair differences in treatment which are not justified by underlying health conditions or treatment preferences.[7] For example, differences in health care due to discrimination or the operation of the health system would constitute a disparity, while differences due to health care needs would not. [7,8,9] To disentangle disparities due to education we would need to appropriately control for differences in clinical need due to comorbidities, age and sex, but not differences in health care due to socio-economic factors like income and class since these may be co-determinant.[10]

A number of mechanisms have been proposed to explain the relationship between education and health care and the proposed disparities analysis identifies the sum of these pathways that are the responsibility of the health care system. Higher education is associated with more desirable behaviors including earlier symptom recognition, more timely care seeking, and better adherence to medicines.[11–13] It is also linked to a range of health promoting behaviors and environments, including better insurance coverage, better access to health facilities, better diet, more exercise,

**Figure 5: Conceptual relationship between education and health care, highlighting the clinical need variables which are controlled for and socio economic factors not controlled for in estimating disparities**



and lower prevalence of conditions such as hypertension, dyslipidemia, and other cardiovascular diseases.[1,13–16]

In the US, race and education tend to be associated. Studies have found that when providers have ethno-linguistic concordancy with more highly educated patients, they may be more attentive and provide better quality of care.[17,18] In addition, demographic factors such as age, marital status, race, and sex may confound the association between education and health.[19] Younger age cohorts may have higher education due to changing social norms and may be healthier due to their younger age. Women may be less likely to be educated, but may be healthier than men of the same age due to biological factors.

In the treatment of chronic diseases, such as diabetes, the link between education and quality of care is especially important. Diabetes affects 285 million adults worldwide, and is projected to increase by 69 percent in developing countries and 20 per cent in developed countries over the next twenty years.[20]Appropriate management of the disease depends in part on clinicians performing recommended processes of care to achieve desired clinical outcomes. Among patients with diabetes, higher education is found to be significantly associated with higher rates of diagnosis and treatment, in Asian and European countries. [5, 21–23,24,25,16]

Most existing studies have assessed the effects of education on diabetes care using self-reported outcomes[24,25] Self-reported health outcomes are subject to recall biases which could be linked to education status.[26] In addition, disparities between health care and education are usually explained using unmatched regression based risk adjustments. These adjustments impose distributional assumptions on the data and, in particular, assume that groups with different educational attainments have similar distributions of other socio-demographic factors like age, sex, marital status. The functional form of the regression extrapolates beyond the area of overlap creating an illusion of common support. Quasi-experimental methods, such as propensity score matching, allows us to more appropriately compare differences in health care. The propensity score reduces the collection of measured potential confounding characteristics to a single composite characteristic on which balance between groups can be achieved via matching.[27]

We tested the effects of education on health care processes and outcomes among a propensity score matched sample of patients with diabetes who had the same social insurance in Mexico City. They were similar in terms of disease, insurance coverage, and ethno-linguistic factors (patients and providers were native Spanish speakers). To assess potential disparities in care due to patient education, we operationalized the IOM framework and matched patients on indicators of health need. We used laboratory test results as measures of intermediate health outcomes. These methods allowed us to answer two questions. First, does higher education lead to better processes and outcomes of care in this context, controlling for appropriate need and preferences? Second, how do traditional regression-based risk adjustments compare with propensity score matching in terms of the magnitude and significance of estimated education effects?

## Methods

### Setting

The study was conducted at the Mexican Social Security Institute (IMSS). IMSS, through a system of health centers and hospitals, provides services to approximately 48 million people who represent about 47 percent of the Mexican population, mainly workers in the formal sector and their families. The IMSS network includes 13,983 family medicine doctors (primary care providers), 19,848 specialists, 1,516 primary health clinics, 240 hospitals and 680 pharmacies across Mexico. Many clinics also have laboratory facilities.

Each IMSS subscriber and his or her family is assigned to a family medical clinic based on residential location. Primary care providers in family medicine clinics provide referrals to secondary and tertiary care facilities within the IMSS network. Subscribers and their family members receive the same benefits. In 2003, IMSS began implementation of an electronic medical record (EMR) in clinics in Mexico City. The VISTA-based[28] EMR includes information on patient demographic and clinical characteristics, and care received at each visit. A dedicated diabetes module in the EMR is intended to capture information on diabetes specific processes of care. EMR data can be linked with other IMSS databases containing patient-specific information on laboratory results.

**Sample and Data**

The study sample consists of 13,855 patients who were older than 19 years of age who visited two family medicine clinics in Mexico City at least once between January 1st and December 31st 2009 and had an ICD-10 diagnosis of type 2 diabetes (T2D) noted in the EMR (E111-E119, E140-E149 and E14X). For these patients, we extracted all EMR and laboratory. We assessed the data for completeness, consistency, and validity (described elsewhere). [29]

**Measures**

*Patient education*

Our main predictor variable of interest is education, categorized into three levels: illiterate and primary school (n=4,575); secondary and high school (n=3,856); and undergraduate and postgraduate (n=1,402). Other educational attainments and missing data were classified as missing (n=4,022). Since increasing educational attainments may have distinct effects on quality of care and clinical outcomes, we created two subgroups: primary versus secondary education in a subgroup including only those individuals and secondary versus tertiary in a second subgroup.[22,27] Each subgroup included an indicator variable contrasting the higher education status with lower education status.

*Demographic and clinical patient characteristics*

We characterized patients according to age (continuous measure in years); sex; marital status (binary variable for married vs. single, divorced, widowed, or in partnership); comorbidities (three indicator variables if had hypertensive disease, dyslipidemia, or other cardio vascular diseases); and fixed effects for clinic (as clinics differed in staffing levels and arrangements for conducting laboratory tests).

To characterize severity of illness, we included measures of last total cholesterol (mg/dl), average body mass index (BMI) between first and last reading ($kg/m^2$), highest fasting glucose level (mg/dl), highest systolic and highest diastolic blood pressure (mmHg) during the three most recent encounters. There is considerable debate whether an average or highest measure of blood glucose and blood pressure best reflect diabetes control status.[30–32] The highest values may better capture severity of disease since even one uncontrolled measurement could indicate a period of poor control and subsequent risk of complications. BMI is considered to be more stable over the course of a year and so we used the average between the first and last measure of BMI during the study period.[33]

*Quality of care outcome indicators*

We used eleven indicators of processes of care and five indicators of clinical outcomes of care. These were based on existing guidelines for diabetes care by National Institute for Clinical Excellence (NICE),[34] American Diabetic Association (ADA),[35] and Health Care Effectiveness Data and Information Set (HEDIS)[36] and adapted to the Mexican context by local members of the study team.[29]

*Process of care indicators*

Process of care indicators included: number of visits with a physician in the primary care clinic; whether a patient had at least three measurements of fasting blood glucose and blood pressure; whether a patient had an order for a comprehensive foot exam; a glucose test; a cholesterol test (if the patient did not have a previous diagnosis of dyslipidemia); and whether the patient was prescribed metformin (if overweight and no documented contraindications); an angiotensin converting enzyme (ACE) inhibitor (if hypertensive and no documented contraindications); aspirin (if above 40 years old with history of smoking, hypertension or dyslipidemia and no documented contraindications); or a statin (if cholesterol measurement greater than 200mg/dl and no documented contraindications.[6]

*Outcome of care indicators*

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[6] Contraindications to metformin: renal failure, respiratory or advanced liver failure, congestive heart failure, coronary artery disease or advanced atherosclerosis, pregnancy, intolerance to metformin; contraindications to inhibitors of angiotensin converting enzyme: intolerance and/or prior treatment failure;, contraindications to acetylsalicylic acid in doses of 75-150mg/day: history of hypersensitivity to aspirin, peptic ulcer disease, and hemophilia; contraindications to statins: hypersensitivity to any component of the drug, active liver disease or unexplained persistent elevations of serum transaminases, pregnancy and lactation.[29]

Indicators of care outcomes were binary measures of glucose levels less than or equal to 130mg/dl in each of the last three measurements; most recent total cholesterol reading under 200mg/dl; systolic blood pressure less than 130mmHg and diastolic pressure less than 80 mmHg in each of the most recent three measurements; and presence of no diabetic complications (diabetic retinopathy, neuropathy, nephropathy, or peripheral vascular disease).

**Statistical analysis**

The unit of analysis was the individual. We described demographic and clinical characteristics and indicators of process and outcome quality by educational attainment. We tested education differences using Pearson's chi square test of independence for binary variables and a one way ANOVA for difference of means for continuous variables. We explored unadjusted differences between educational attainment and the 16 process and outcome indicators.

*Propensity score matching*

Adjusted differences between education and outcomes were calculated using Mahalanobis matching with calipers defined by propensity score.[37–40] This matching algorithm has been shown to be a robust method to achieve covariate balance.[37] For ease of interpretation, we contrasted primary education versus with secondary education only; and secondary education versus tertiary education only (dropping missing observations for this stage of the analysis). Comparing primary education versus tertiary education was not suitable as patients differed significantly on most variables and there was little overlap of these patient groups.

First, we predicted the propensity score or probability of having attained a higher educational attainment using demographic variables, comorbidities and clinic fixed effects. The final model included age as linear and quadratic terms to better capture the non-linear association between age and education. The logit function of this predicted probability is considered the propensity score. [27] We plotted the kernel density of the propensity score for those with a primary education and those with a secondary education. The two kernel densities showed a large amount of overlap indicating significant potential for matches (see Web Appendix Figure 7). This is because a person with primary and a person with secondary education who have the same propensity score are essentially viewed as comparable, even though they may differ on values of specific covariates.[40] We repeated this for tertiary education versus secondary education.

Next, we used nearest available Mahalanobis matching with replacement and within calipers defined by 0.25 times the standard error of the propensity score to create matched samples which were balanced on age, sex, marital status, comorbidities and clinic, but differed in terms of actual educational attainment and other differences such as income, class etc. We determined balance of matching covariates through t-tests of difference of proportions and subsequent change in bias.

Finally, to evaluate the magnitude and significance of the relationship between education and each outcome, we calculated the percentage point difference in the full matched sample for higher versus lower educational attainment. The average effect was calculated from the full sample match. The variance was calculated through a process of bootstrapping. A thousand random samples of the original distributions were chosen with replacement and the propensity score, matching algorithm, and effect were re-estimated. This resulted in a distribution of effect estimates, which was approximately normal. The 2.5$^{th}$ and 97.5$^{th}$ percentile values of this distribution were used to construct 95 per cent confidence intervals.[41]

We used Stata 12.0 (Texas, Stata Corp) for all analyses; and the psmatch2 and pstest suite of commands for matching.[42] We considered $p < 0.05$ as statistically significant.

**Sensitivity analyses**

*Unmatched regression based risk adjustments versus propensity score methods*

To answer our second question, we compared the magnitude and significance of estimates from propensity score matched results to unmatched regression based risk adjustment. For binary outcomes, we used logistic regression models to estimate associations between education (conducted pair wise) and outcomes, controlling for matching variables (demographic, comorbidities, and clinic fixed effects). For outcomes which were only relevant to a specific group, eg prescribed metformin if obese, we only performed the regression on the relevant group (here only on obese).

*Other Sensitivity based analyses*

We conducted sensitivity analyses to test the specifications of our models. We explored different regression models to best predict the propensity score and compared the goodness of fit and balance of each model. We also calculated approximate standard errors versus bootstrapped standard errors; and 100 bootstrapped iterations versus 500 or 1000 runs.

The Harvard Pilgrim Health Care Human Studies Committee and the IMSS Research Ethical Committee of the IMSS Research Review Board approved this study.

**Results**

**Characteristics of the study population**

Patients with diabetes with different educational attainments differed in terms of demographic and clinical characteristics. Patients who were illiterate or had primary school education were significantly more likely to be unmarried older women who visited clinic one. They were also more likely to have hypertension and less likely to have cardio vascular disease or dyslipidemia than patients with secondary or tertiary educational attainment (Table 7).

Of the total population, 4,022 had data missing on educational attainment and so were dropped from the calculation of effect estimates. This missing population tended to be more similar to the secondary school education group in terms of demographic characteristics and clinical indicators.

On matching on select covariates the percent change in bias ranged from 89.5 to 100.0 percent. In the full matched sample, this was achieved by dropping 137 (1.7 per cent) secondary education observations in the primary versus secondary comparison and 26 (0.5 per cent) tertiary education observations in the tertiary versus secondary observations.

**Unadjusted outcomes disaggregated by education and sex**

Process of care indicators differed by patient educational attainment. Physicians were more likely to order diagnostic tests (comprehensive foot exams, ophthalmologist referrals and glucose tests) for patients who were illiterate or had primary schooling than for patients with higher education (secondary or tertiary education). They were less likely to prescribe metformin for obese patients with lower educational attainment but there were no significant differences in prescribing of aspirin, statins, and ACE inhibitors (Table 8).

Conversely, patients with higher education had better clinical outcome indicators than those with lower education. Patients with an undergraduate or graduate degree were significantly more

**Table 7: Descriptive characteristics of sample by education status**

| | Illiterate/ Primary School | Secondary/ High School | Undergraduate / Postgraduate | Education Status Missing | p-value |
|---|---|---|---|---|---|
| | (n= 4,575) | (n=3,856) | (n=1,402) | (n=4,022) | |
| **Demographic characteristics** | | | | | |
| Male (%) | 30.4 | 40.1 | 68.8 | 45.7 | 0.0000 |
| Age (mean, years) | 67.8 | 61.2 | 61.5 | 62.0 | 0.0000 |
| Married (%) | 52.8 | 60.7 | 69.2 | . | 0.0000 |
| In Clinic 2 (%) | 36.6 | 50.3 | 59.1 | 55.5 | 0.0000 |
| | | | | | |
| **Clinical characteristics** | | | | | |
| Hypertension (%) | 74.8 | 68.4 | 68.8 | 51.2 | 0.0000 |
| Dyslipidemia (%) | 47.0 | 53.8 | 53.9 | 37.5 | 0.0000 |
| Other cardio vascular disease (%) | 12.9 | 11.7 | 15.8 | 10.7 | 0.0000 |
| | | | | | |
| Total cholesterol level (mean, mg/dl) | 200.6 | 201.7 | 197.9 | 201.7 | 0.0833 |
| Average body mass index of two readings (mean, kg/m2) | 29.2 | 29.5 | 28.9 | 29.0 | 0.0000 |
| Highest fasting blood glucose of three readings (mean, mg/dl) | 181.7 | 175.8 | 167.7 | 178.8 | 0.0000 |
| Highest systolic blood pressure of three readings (mean, mmHg) | 131.7 | 129.6 | 129.8 | 128.2 | 0.0000 |
| Highest diastolic blood mean, pressure of three readings (mmHg) | 81.1 | 81.1 | 81.0 | 80.1 | 0.0414 |

**Table 8: Unadjusted associations between education and quality of care ***

| | **Illiterate/ Primary School** | **Secondary/ High School** | **Undergraduate/ Undergrad/Postgraduate** | **Missing** |
|---|---|---|---|---|
| | (n=4,575) | (n=3,856) | (n=1,402) | (n=4,022) |
| **Processes of Care** | | | | |
| 1. Number of visits with family doctor in 2009 (mean) | 9.9 | 9.96 | 9.56 | 7.0 |
| | [9.78;10.01] | [9.80;10.11] | [9.33;9.79] | [6.85;7.15] |
| 2. Comprehensive foot exam | 5.9 | 5.5 | 5.2 | 0.01 |
| | [0.58;0.61] | [0.53;0.56] | [0.50;0.55] | [0.01;0.01] |
| 3. Referral to ophthalmologist | 0.22 | 0.2 | 0.18 | 0.13 |
| | [0.21;0.23] | [0.19;0.21] | [0.16;0.20] | [0.12;0.14] |
| 4. Glucose test ordered | 0.78 | 0.74 | 0.68 | 0.62 |
| | [0.77;0.79] | [0.73;0.76] | [0.66;0.71] | [0.60;0.63] |
| 5. At least 3 glucose measurements | 0.5 | 0.42 | 0.37 | 0.24 |
| | [0.49;0.52] | [0.40;0.43] | [0.34;0.39] | [0.23;0.26] |
| 6. At least 3 blood pressure measurements | 0.94 | 0.93 | 0.91 | 0.73 |
| | [0.93;0.95] | [0.92;0.94] | [0.90;0.93] | [0.71;0.74] |
| 7. Cholesterol measurement among patients' with dyslipidemia | 0.68 | 0.65 | 0.62 | 0.49 |
| | [0.66;0.70] | [0.62;0.67] | [0.58;0.66] | [0.47;0.51] |

**Table 8 (continued)**

| | Illiterate/ Primary School | Secondary/ High School | Undergraduate/ Undergrad/Postgraduate | Missing |
|---|---|---|---|---|
| | (n=4,575) | (n=3,856) | (n=1,402) | (n=4,022) |
| 8.Metformin prescribed among overweight patients without contraindications | 0.58 | 0.64 | 0.65 | 0.56 |
| | [0.57;0.60] | [0.62;0.66] | [0.62;0.68] | [0.54;0.58] |
| 9. ACEI prescribed among patients with hypertension without contraindications | 0.55 | 0.54 | 0.53 | 0.56 |
| | [0.54;0.57] | [0.52;0.56] | [0.50;0.57] | [0.54;0.58] |
| 10. Aspirin prescribed among patients over 40 years with risk factors and without contraindications | 0.42 | 0.37 | 0.40 | 0.36 |
| | [0.41;0.44] | [0.36;0.39] | [0.37;0.43] | [0.34;0.37] |
| 11. Statins prescribed among patients with total cholesterol > 200mg/dl and without contraindications | 0.5 | 0.51 | 0.53 | 0.48 |
| **Clinical Outcomes** | [0.48;0.52] | [0.49;0.54] | [0.49;0.58] | [0.45;0.51] |
| 12. Glucose < 130mg/dl in each of last three measurements | 0.19 | 0.21 | 0.25 | 0.22 |
| | [0.17;0.20] | [0.19;0.23] | [0.22;0.29] | [0.20;0.25] |
| 13. Total cholesterol < 200mg/dl | 0.52 | 0.51 | 0.56 | 0.52 |
| | [0.50;0.54] | [0.49;0.53] | [0.53;0.59] | [0.50;0.54] |

| Table 8 (continued) | | | | |
|---|---|---|---|---|
| | **Illiterate/ Primary School** | **Secondary/ High School** | **Undergraduate/ Undergrad/Postgraduate** | **Missing** |
| | (n=4,575) | (n=3,856) | (n=1,402) | (n=4,022) |
| 14. Systolic pressure < 130mmHg in each of last three measurements | 0.38 | 0.42 | 0.40 | 0.48 |
| | [0.36;0.39] | [0.41;0.44] | [0.37;0.43] | [0.46;0.50] |
| 15. Diastolic pressure less than 80mmHg in each of last three measurements | 0.14 | 0.13 | 0.12 | 0.13 |
| | [0.13;0.15] | [0.12;0.14] | [0.11;0.14] | [0.12;0.14] |
| 16. No diabetic complications± | 0.65 | 0.70 | 0.73 | 0.76 |
| | [0.64;0.66] | [0.69;0.72] | [0.70;0.75] | [0.74;0.77] |
| 95% Confidence intervals in parentheses | | | | |

*Unless otherwise noted, all entries represent proportions of patients having the respective indicator; ± Diabetic complications are defined as having an ICD-10 code for diabetic retinopathy, neuropathy, nephropathy, or peripheral vascular disease during the study period. ACEI= angiotensin converting enzyme inhibitor likely to have glucose levels under 130mg/dl and less likely to have a diabetes-related complication than patients who were illiterate or had primary schooling. There were no significant differences between male and females for most outcomes within the same educational attainment (Web Appendix Table 10).

**Adjusted associations based on propensity-score matched sample**

*Processes of care*

For the estimates derived from the propensity score matched samples, there were few significant differences in process of care indicators between patients with different education levels, although the direction of estimates tended to indicate those with lower educational levels had better processes of care (Table 9a). For example, patients with no or primary school education were 7.6 (4.1, 12.1) percentage points more likely to have three glucose measurements than patients with secondary or high school education. Similarly patients with secondary or high school education were 4.8 (0.6, 10.2) percentage points more likely to have a glucose test ordered than patients with undergraduate or postgraduate education. Even though not significant, primary physicians tended to order more diagnostics for those with a lower education level than a higher education level including ordering more foot exams, taking at least three measures of glucose blood pressure, and referring to an ophthalmologist.

*Clinical outcomes of care*

There were few significant differences in outcomes of care by educational attainment, although the direction of effects indicated patients with higher education tended to have better outcomes.

Patients with an undergraduate or post graduate education were 7.4 (1.8, 12.4) percentage points less likely to have complications due to diabetes than patients with a secondary or high school degree.

**Sensitivity Analyses**

The most predictive model for propensity score included the non linear effects of age as a squared term but did not include interaction terms of age and sex. The approximate standard errors were narrower than the bootstrapped standard errors. This is because the approximate standard errors impose a number of assumptions-- independent observations, homoskedasticity of the outcome variable within different education levels and variance of the outcome does not depend on the propensity score.[42] It also does not take into account that the propensity score is estimated.100 bootstrapped iterations were less stable than 500 iterations, but there was little difference between 500 and 1000 iterations.

Unmatched regression-adjusted estimates showed a greater number of outcomes with significant differences by educational attainment than propensity score matching (Table 9b). Of the 32 outcomes studied (16 outcomes each for two subgroups), the unmatched regression risk adjusted estimates showed education to have a significant effect on ten versus four outcomes using propensity scores. When we compared the size of the effect estimates between the two methods, 9 of the 32 outcomes had significantly different effect sizes if calculated by regression risk adjustment as opposed to propensity scores (Figure 6). In most cases the (5/9) the propensity score estimate was closer to the null and the unmatched regression estimate tended to be higher. The bootstrapped confidence intervals around the propensity score estimate tended to be much wider than those around the regression estimates, possible because the propensity score method was accounting for more uncertainty.

**Discussion**

In this population of patients with diabetes in Mexico City we find few disparities due to education in the processes and outcomes of care received in models using propensity adjusted estimates and a greater number of disparities using traditional estimation methods. These findings are unique, both from methodological and a policy perspective. To our knowledge, this is the first study to apply a robust quasi-experimental technique like Mahanolobian matching

| Table 9a: Differences in processes and outcomes of care based on propensity score matched adjusted models | | |
|---|---|---|
| | **Secondary or High School - Illiterate or Primary School**<br><br>**Absolute Difference [95% CI] (n=8,228)** | **Undergraduate or Post Graduate - Secondary or High School**<br><br>**Absolute Difference [95% CI] (n=5,114)** |
| **Processes of Care** | | |
| 1. Number of visits with family doctor in 2009 (mean) | 0.18 [- 0.17, 0.45] | **-0.70 [-1.09, -0.05]**** |
| **Absolute difference (percentage point)** | **(percentage points)** | **(percentage points)** |
| 2. Comprehensive foot exam | -3.27 [-7.28, 0.20]* | -0.75 [-5.45, 4.82] |
| 3. Referral to ophthalmologist | -0.61 [-1.88, 4.12] | -1.12 [-6.25, 2.31] |
| 4. Glucose test ordered | -0.86 [-4.75, 1.85] | **-4.78 [-10.21, -0.58]**** |
| 5. At least 3 glucose measurements | **-7.64 [-12.09, -4.08]**** | -2.69 [-8.49, 1.43] |
| 6. At least 3 blood pressure measurements | -0.64 [-1.83, 1.64] | -1.94 [-4.38, 1.14] |
| 7. Cholesterol measurement among patients' with dyslipidemia | 0.06 [-7.58, 2.17] | 0 [-10.22, 3.75] |
| 8.Metformin prescribed among overweight patients without contraindications | -0.89 [ -4.22, 4.68] | 3.92 [ -2.21, 7.64] |
| 9. ACEI prescribed among patients with hypertension without contraindications | -4.03 [ -7.92, 1.71] | -3.31 [-10.43, 3.01] |
| 10. Aspirin prescribed among patients over 40 years with risk factors and without contraindications | -0.39 [-5.52, 2.78] | 0.76 [-4.42, 6.99] |
| 11. Statins prescribed among patients with total cholesterol > 200mg/dl and without contraindications | 3.74 [ -4.05, 7.17] | 2.91 [-5.54, 11.67] |
| | | |

| Table 9a (Continued) | | |
|---|---|---|
| **Clinical Outcomes** | **Illiterate or Primary School vs Secondary or High School**<br><br>**Absolute Difference [95% CI]**<br><br>(percentage points) | **Undergraduate or Post Graduate vs. Secondary or High School**<br><br>**Absolute Difference [95% CI]**<br><br>(percentage points) |
| 12. Glucose < 130mg/dl in each of last three measurements | 1.23 [-0.90, 7.63] | 4.20 [-2.17, 12.56] |
| 13. Total cholesterol < 200mg/dl | 0.71 [-3.77, 4.97] | 2.50 [-3.06, 8.90] |
| 14. Systolic pressure < 130mmHg in each of last three measurements | 1.45 [-2.61, 5.26] | -1.31 [-6.54, 4.21 ] |
| 15. Diastolic pressure less than 80mmHg in each of last three measurements | -0.27 [-2.99, 2.50] | 1.23 [-3.18, 4.63] |
| 16. No diabetic complications± | 1.74 [-0.79, 6.63] | **7.40 [1.78, 12.39]**** |

# Results are presented as the average value for patients with higher educational attainment minus average value for patients with lower educational attainment (95% Confidence Interval based on 1000 bootstrap iterations); unless otherwise noted, entries represent absolute percentage point differences

± Diabetic complications are defined as having an ICD-10 code for diabetic retinopathy, neuropathy, nephropathy, or peripheral vascular disease; * significant at p<0.10; ** significant at p<0.05

| Table 9b: Differences in processes and outcomes of care based on unmatched regression based risk adjustments | | |
|---|---|---|
| | **Secondary or High School - Illiterate or Primary School**<br><br>**Absolute Difference [95% CI] (n=8,228)** | **Undergraduate or Post Graduate - Secondary or High School**<br><br>**Absolute Difference [95% CI] (n=5,114)** |
| **Processes of Care** | | |
| 1. Number of visits with family doctor in 2009 (mean) | 0.10[- 0.09, 0.29] | **-0.55 [-0.84, -0.26]**** |
| **Percentage point change: Absolute difference** | **(percentage points)** | **(percentage points)** |
| 2. Comprehensive foot exam | **-3.15 [-5.32, -0.98]**** | 0.07 [-2.98, 3.13] |
| 3. Referral to ophthalmologist | 0.76[-1.11, 2.63] | -1.26 [-3.80, 1.20] |
| 4. Glucose test ordered | **-2.62 [-4.53, -0.71]**** | **-5.18 [-7.99, -2.36]**** |
| 5. At least 3 glucose measurements | **-8.61 [-10.85, -6.38]**** | 2.77 [-5.86, 0.31]* |
| 6. At least 3 blood pressure measurements | -0.25 [-1.34, 0.83 ] | **-2.11 [ -3.72, -0.49]**** |
| 7. Cholesterol measurement among patients' with dyslipidemia | -2.64 [-5.71, 0.42]* | -1.96 [-6.49, 2.57] |
| 8.Metformin prescribed among overweight patients without contraindications | -0.28[-2.83, 2.27] | 1.64 [ -2.00, 5.29] |
| 9. ACEI prescribed among patients with hypertension without contraindications | **-3.82 [ -6.48, -1.15]**** | -3.26 [-7.10, 0.58]* |
| 10. Aspirin prescribed among patients over 40 years with risk factors and without contraindications | -1.65 [-4.07, 0.78] | 1.64 [-1.85, 5.13] |
| 11. Statins prescribed among patients with total cholesterol > 200mg/dl and without contraindications | 0.82 [ -2.83, 4.48] | 2.45 [-2.96, 7.85] |
| | | |

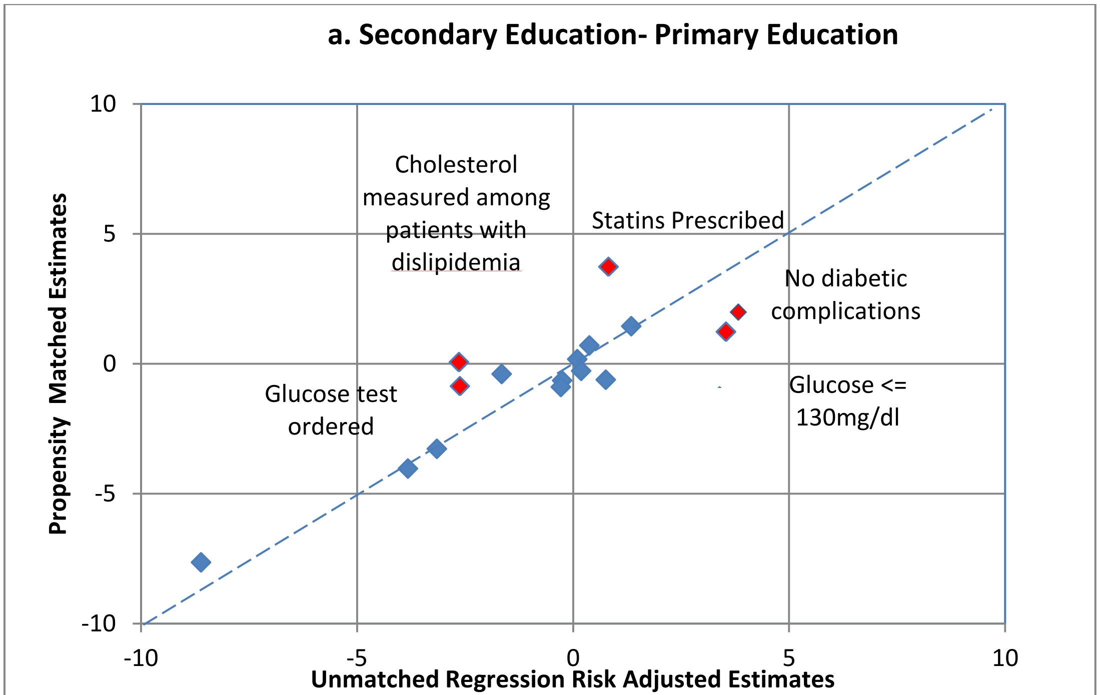
**Table 9b (Continued)**

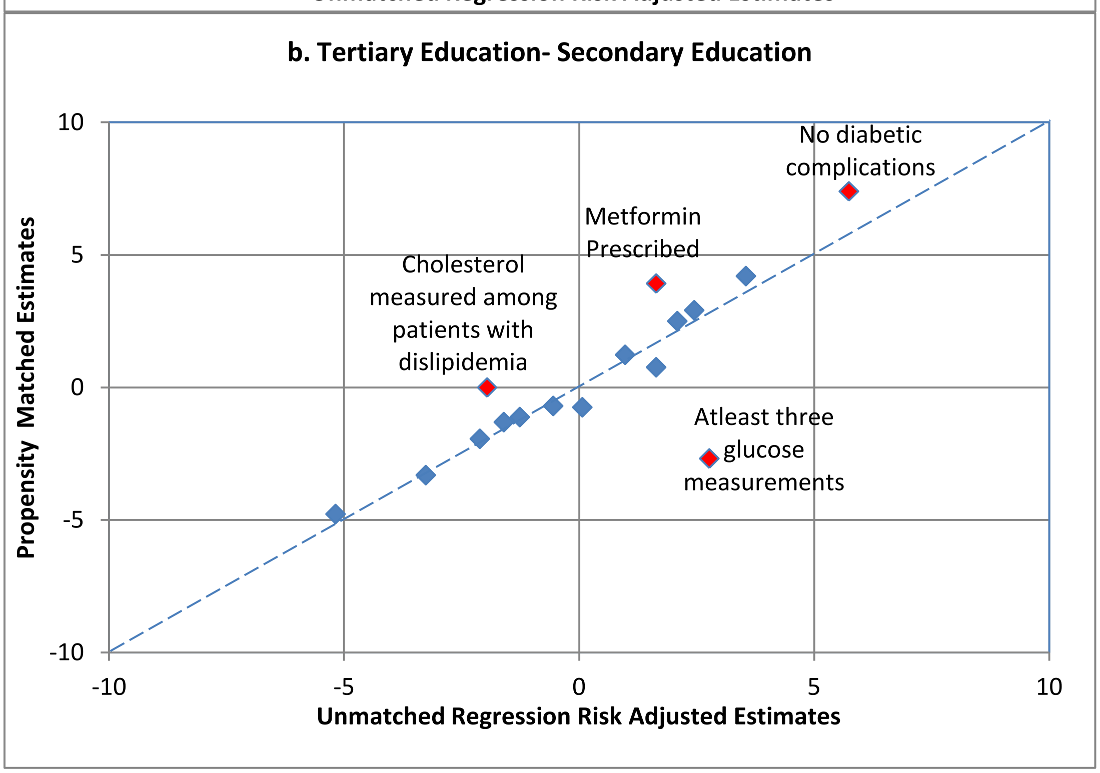
| **Clinical Outcomes** | **Illiterate or Primary School vs Secondary or High School**<br><br>**Absolute Difference [95% CI]**<br><br>(percentage points) | **Undergraduate or Post Graduate vs. Secondary or High School**<br><br>**Absolute Difference [95% CI]**<br><br>(percentage points) |
|---|---|---|
| 12. Glucose < 130mg/dl in each of last three measurements | | |
| 13. Total cholesterol < 200mg/dl | **3.54 [0.83, 6.26]**** | 3.55 [-0.71, 7.82] |
| 14. Systolic pressure < 130mmHg in each of last three measurements | 0.38 [-2.25, 3.01] | 2.09 [-1.66, 5.85] |
| 15. Diastolic pressure less than 80mmHg in each of last three measurements | 1.35 [-0.88, 3.58] | -1.60 [ -4.77, 1.58] |
| 16. No diabetic complications± | 0.19 [-1.40, 1.77] | 0.98 [-1.23, 3.18] |
| | **3.39 [1.25, 5.52]**** | **5.74 [2.84, 8.64]**** |

# Results are presented as the average value for patients with higher educational attainment minus average value for patients with lower educational attainment (95% Confidence Interval based on 1000 bootstrap iterations); unless otherwise noted, entries represent absolute percentage point differences

± Diabetic complications are defined as having an ICD-10 code for diabetic retinopathy, neuropathy, nephropathy, or peripheral vascular disease; * significant at p<0.10; ** significant at p<0.05

**Fig 6: Comparing Estimates.** Propensity score matched versus unmatched regression risk adjusted estimates. When propensity score and regression effect estimates are the same they fall on the 45$^{o}$ line



with calipers defined by propensity scores to better explore the relationship between education and health care.

From the methodological perspective, we show that unmatched regression based estimates may tend to overestimate the magnitude and significance of the effect of education on processes and clinical outcomes of care as compared to propensity score matched methods. Through the matching process we dropped individuals who had similar levels of education, but very different health needs (as captured by demographic and clinical variables), making them not suitable to be compared. Assuming common support through use of regression methods may have produced biased estimates.

From a policy perspective, our results suggest that when appropriately adjusted for, education is associated with very few significant differences in processes of care and clinical outcomes. Patients with lower educational attainment had only one notably worse outcome: patients with a university education tended to have fewer complications from diabetes than patients with secondary or high school education. Although not always significant, more patients with lower education received interventions we had defined as quality processes of care, and fewer had the desired care outcomes, compared to patients with higher education.

However, the study is subject to key limitations. There were substantial problems in the completeness and accuracy of the data in the electronic medical record noted during the course of the study. The study team attempted to minimize this source of error through extensive quality checking.[29] To the extent that these errors are distributed randomly across patients with different educational levels, the consequence would be to bias the education effect sizes toward the null.

The external validity of our study may be limited because we chose a sample of patients who received care at two purposively selected clinics in Mexico City. This setting may be unique in that the population was homogenous in terms of insurance status, benefits provided, and ethno-linguistic concordance between patients and providers, a reason it was selected. The sample of patients dropped from our analyses due to missing data on educational level, tended to have similar demographic and clinical values as those with a secondary education (where data was available). If we had less missing data for each person we could have imputed the data and performed a sensitivity analysis, but as such we had to perform casewise deletion. As physicians get more used to the EMR, data entry and extraction should improve to reduce missing data. Future research should repeat our analyses across a wider variety of IMSS clinics in Mexico.

The variance of the propensity score estimates could be subject to bias. The estimated variance of the treatment effect includes three sources of uncertainty due to derivation of the propensity score, determination of common support, and the order in which treated individuals are matched.[43] There is no agreed-upon method to capture these sources of uncertainty, with bootstrapping being one method that has been suggested;[44,45]however, formal justification for bootstrap estimators is limited.[46] Since the estimators are asymptotically linear and our outcomes are binary, we believe that bootstrapping has likely led to valid standard errors and confidence intervals.[47] The standard errors of the bootstrap estimates are large, and future research should focus on ways to produce tighter confidence bounds.

**Conclusion**

We examined education as a predictor of disparities in quality of care for diabetic patients in Mexico using traditional and propensity-score matched estimation methods. In a setting where the population is homogenous in terms of insurance coverage, locations of care, and ethno-linguistic concordance, we show that effects of education on processes and outcomes of care are few when estimated based on propensity score methods and may be overestimated by unmatched regression methods.

Low and middle-income countries like Mexico have a rapidly rising burden of chronic illnesses, placing strains on national health systems and quality of care.[48] Studies in these settings show that the burden of chronic disease is unequally distributed and disproportionately falls on those in the lower social economic strata.[49,50] It is important to understand the role of education in influencing quality of care in these contexts. Our results suggest that characteristics other than education may be more important for identifying patients in need of targeted interventions to improve quality of care and outcomes.

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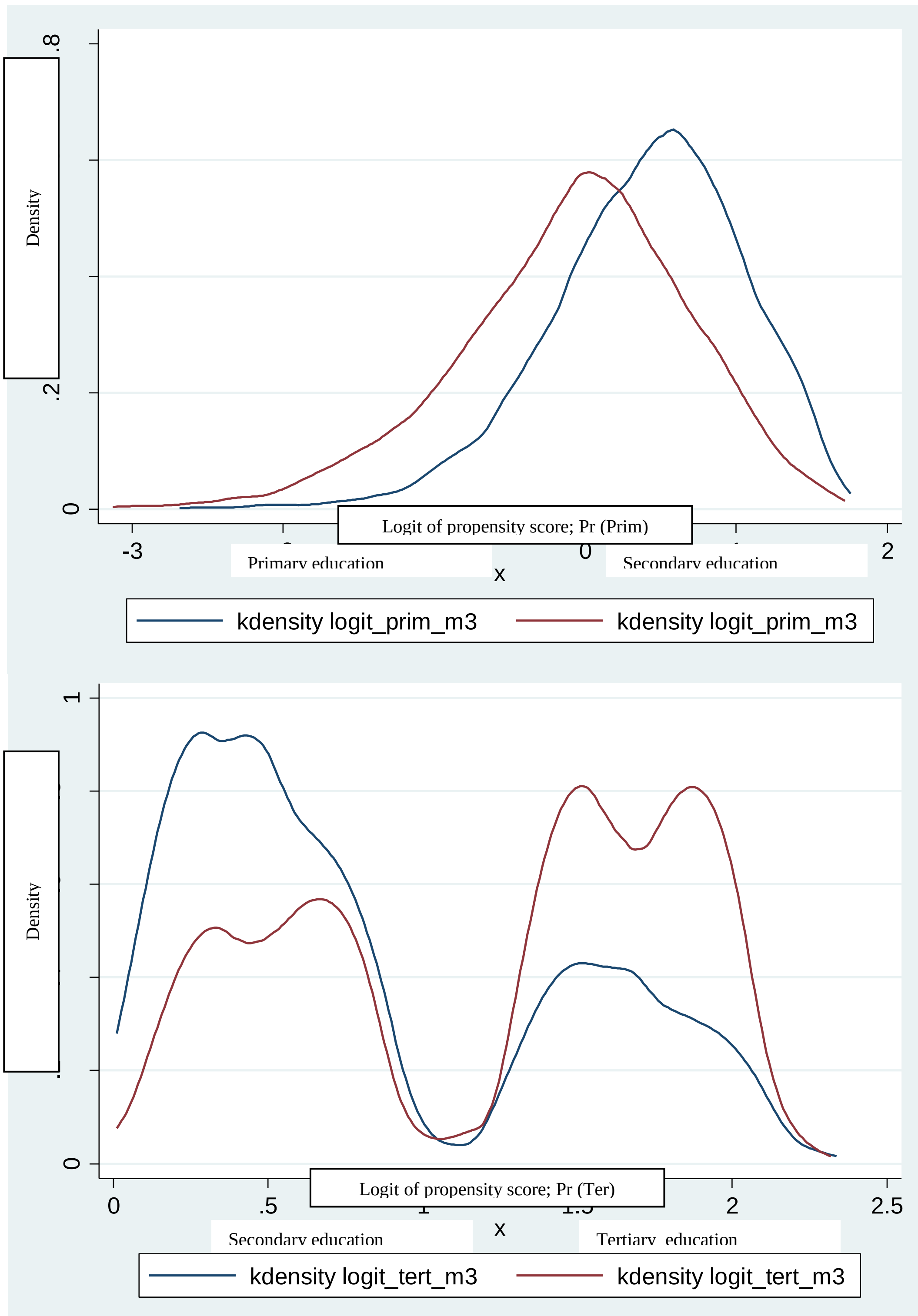
**Web Appendix Fig 7: Propensity score estimation**: Large amount of overlap shows significant common support region, which is indicative of a high likelihood of matches between both groups.



**Web Appendix Table 10: Unadjusted associations between education and outcomes, disaggregated by gender**

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | **Illiterate/ Primary School** | **Secondary/ High School** | **Undergrad /Post Grad** | **Missing** | **Illiterate/ Primary School** | **Secondary/ High School** | **Undergrad/Post Grad** | **Missing** |
| **Processes of Care** | *(n= 1,391)* | *(n= 1,545)* | *(n= 965)* | *(n= 1,837)* | *(n= 3,184)* | *(n= 2,311)* | *(n= 437)* | *(n= 2,185)* |
| 1. Number of visits with family doctor in 2009 (mean) | 9.55 | 9.79 | 9.52 | 6.6 | 10.04 | 10.07 | 9.64 | 7.34 |
| | [9.32;9.79] | [9.52;10.06] | [9.23;9.80] | [6.37;6.82] | [9.91;10.18 ] | [9.89;10.26] | [9.26;10.02] | [7.15;7.53 ] |
| 2. Comprehensive foot exam | 0.61 | 0.56 | 0.52 | 0.01 | 0.59 | 0.54 | 0.53 | 0.01 |
| | [0.58;0.63] | [0.53;0.58] | [0.49;0.55] | [0.00;0.01] | [0.57;0.61] | [0.52;0.56] | [0.48;0.58] | [0.01;0.02 ] |
| 3. Referral to ophthalmologist | 0.21 | 0.2 | 0.19 | 0.12 | 0.23 | 0.21 | 0.17 | 0.13 |
| | [0.19;0.23] | [0.18;0.22] | [0.16;0.21] | [0.10;0.13] | [0.21;0.24] | [0.19;0.22] | [0.13;0.20] | [0.12;0.15 ] |
| 4. Glucose test ordered | 0.76 | 0.75 | 0.68 | 0.61 | 0.79 | 0.74 | 0.68 | 0.63 |
| | [0.74;0.78] | [0.73;0.77] | [0.65;0.71] | [0.58;0.63] | [0.77;0.80] | [0.72;0.76] | [0.64;0.73] | [0.60;0.65 |

**Web Appendix Table 10 (Continued)**

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ] |
| 5. At least 3 glucose measurements | 0.47 | 0.41 | 0.36 | 0.22 | 0.52 | 0.42 | 0.39 | 0.26 |
| | [0.44;0.49] | [0.38;0.43] | [0.33;0.39] | [0.20;0.24] | [0.50;0.53] | [0.40;0.44] | [0.34;0.43] | [0.24;0.28 ] |
| 6. At least 3 blood pressure measurements | 0.93 | 0.92 | 0.91 | 0.68 | 0.94 | 0.94 | 0.92 | 0.76 |
| | [0.92;0.94] | [0.91;0.93] | [0.89;0.93] | [0.66;0.70] | [0.93;0.95] | [0.93;0.95] | [0.89;0.95] | [0.75;0.78 ] |
| 7. Cholesterol measurement among patients' with dyslipidemia | 0.64 | 0.66 | 0.61 | 0.46 | 0.7 | 0.64 | 0.64 | 0.51 |
| | [0.61;0.68] | [0.62;0.69] | [0.57;0.66] | [0.43;0.49] | [0.67;0.72] | [0.61;0.67] | [0.57;0.71] | [0.48;0.54 ] |
| 8.Metformin prescribed among overweight patients without contraindications | 0.55 | 0.59 | 0.63 | 0.54 | 0.6 | 0.67 | 0.68 | 0.57 |
| | [0.52;0.58] | [0.56;0.62] | [0.59;0.66] | [0.51;0.57] | [0.58;0.62] | [0.65;0.69] | [0.63;0.73] | [0.54;0.59 ] |

**Web Appendix Table 10 (Continued)**

| | **Male** | | | | **Female** | | | |
|---|---|---|---|---|---|---|---|---|
| 9. ACEI prescribed among patients with hypertension without contraindications | 0.63 | 0.58 | 0.57 | 0.61 | 0.52 | 0.52 | 0.47 | 0.52 |
| | [0.60;0.66] | [0.55;0.62] | [0.53;0.60] | [0.58;0.64] | [0.50;0.54] | [0.49;0.54] | [0.41;0.52] | [0.49;0.55] |
| 10. Aspirin prescribed among patients over 40 years with risk factors and without contraindications | 0.45 | 0.4 | 0.43 | 0.39 | 0.41 | 0.36 | 0.34 | 0.33 |
| | [0.43;0.48] | [0.37;0.43] | [0.39;0.46] | [0.36;0.42] | [0.39;0.43] | [0.34;0.38] | [0.29;0.39] | [0.31;0.36] |
| 11. Statins prescribed among patients with total cholesterol > 200mg/dl and without contraindications | 0.49 | 0.53 | 0.53 | 0.54 | 0.5 | 0.5 | 0.54 | 0.45 |
| | [0.44;0.54] | [0.49;0.58] | [0.47;0.59] | [0.49;0.58] | [0.48;0.53] | [0.47;0.54] | [0.46;0.62] | [0.42;0.49] |
| **Clinical Outcomes** | | | | | | | | |
| 12. Glucose < 130mg/dl in each of last three | 0.19 | 0.23 | 0.25 | 0.2 | 0.19 | 0.2 | 0.25 | 0.23 |

**Web Appendix Table 10 (Continued)**

| | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| measurements | | | | | | | | |
| | [0.16;0.22] | [0.20;0.26] | [0.21;0.30] | [0.17;0.24] | [0.17;0.21] | [0.17;0.22] | [0.19;0.32] | [0.20;0.27] |
| 13. Total cholesterol < 200mg/dl | 0.64 | 0.57 | 0.58 | 0.59 | 0.47 | 0.48 | 0.51 | 0.47 |
| | [0.61;0.67] | [0.54;0.59] | [0.54;0.62] | [0.56;0.62] | [0.45;0.49] | [0.45;0.50] | [0.46;0.57] | [0.44;0.49] |
| 14. Systolic pressure < 130mmHg in each of last three measurements | 0.38 | 0.43 | 0.38 | 0.47 | 0.37 | 0.42 | 0.44 | 0.49 |
| | [0.36;0.41] | [0.41;0.46] | [0.35;0.41] | [0.44;0.49] | [0.36;0.39] | [0.40;0.44] | [0.39;0.49] | [0.46;0.51] |
| 15. Diastolic pressure less than 80mmHg in each of last three measurements | 0.12 | 0.12 | 0.13 | 0.14 | 0.14 | 0.13 | 0.1 | 0.13 |
| | [0.10;0.14] | [0.10;0.14] | [0.11;0.16] | [0.12;0.15] | [0.13;0.16] | [0.12;0.15] | [0.07;0.13] | [0.11;0.14] |
| 16. No diabetic complications± | 0.38 | 0.35 | 0.31 | 0.26 | 0.34 | 0.26 | 0.2 | 0.23 |

**Web Appendix Table 10 (Continued)**

| | **Male** | | | | **Female** | | | |
|---|---|---|---|---|---|---|---|---|
| | [0.36;0.41] | [0.33;0.38] | [0.28;0.33] | [0.24;0.28] | [0.32;0.35] | [0.25;0.28] | [0.16;0.24] | [0.21;0.25 ] |

95% Confidence intervals in parenthesis

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